NAVSHIPS 0967-163-9040 (*Non-Registered*)

VOLUME 4

TECHNICAL MANUAL

for

RADIO SET AN/SRC-23(V)

CHAPTERS K THROUGH N

DEPARTMENT OF THE NAVY

NAVAL SHIP SYSTEMS COMMAND

NAVSHIPS 0967-163-9040 (*Non-Registered*)

VOLUME 4

TECHNICAL MANUAL

for

RADIO SET AN/SRC-23(V)

CHAPTER K

FREQUENCY STANDARD GROUP

OA-4792/SRC-23(V)

DEPARTMENT OF THE NAVY

NAVAL SHIP SYSTEMS COMMAND

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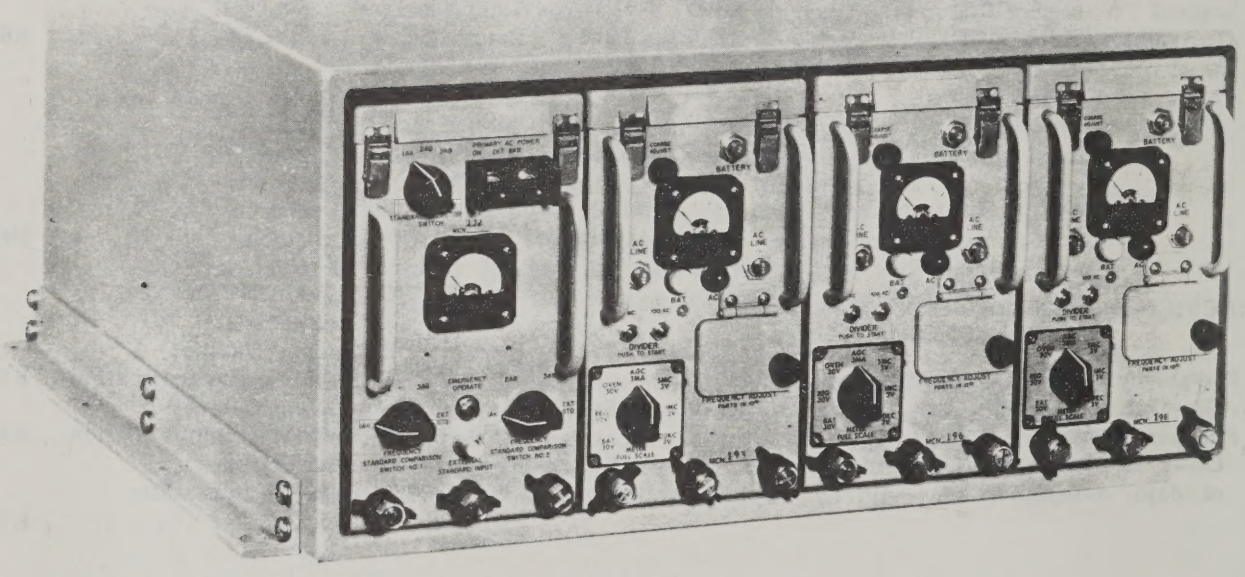


Figure 1-1. Frequency Standard Group OA-4792/SRC-23(V)

SECTION 1

GENERAL INFORMATION

1-1. SCOPE.

This chapter describes Frequency Standard Group OA-4792/SRC-23(V). The group consists of Signal Comparator CM-270/SRC-16 and three Frequency Standards O-1107/SRC-16, which are installed in Electrical Equipment Cabinet CY-4029/SRC-23(V). The signal comparator is described in chapter M, and the frequency standard is described in chapter L. This chapter describes the signal comparator and the three frequency standards as a group, treating the signal comparator and frequency standards as modular units. This chapter includes general information, troubleshooting procedures, and maintenance procedures. Installation procedures are contained in chapter A, section 2 (volume 1). Parts list information is contained in chapter O (volume 5). This chapter is in effect upon receipt. Extracts may be made to facilitate the preparation of other Department of Defense Publications.

1-2. RELATED PUBLICATIONS.

Preventive maintenance schedules and procedures are contained in the Maintenance Standards book for Radio Set AN/SRC-23(V), NavShips 0967-163-9070.

1-3. GENERAL DESCRIPTION.

Frequency Standard Group OA-4792/SRC-23(V) (figure 1-1) consists of Signal Comparator CM-270/SRC-16 (signal comparator) and three Frequency Standards O-1107/SRC-16 (frequency standards), which are installed in Electrical Equipment Cabinet CY-4029/SRC-23(V). These units are located in the cabinet as shown in figure 1-2. Each frequency standard provides a 100-kc signal. The signal comparator is a modular transistorized unit which compares any two of four 100-kc inputs. These four inputs consist of input signals from each of the three frequency standards and one input from an external frequency standard. The comparison is accurate to 1 part in 10^9. When a highly stable external 100-kc frequency standard is available, each frequency standard can be compared to the external frequency standard. If an external standard is not available, the output of each O-1107/SRC-16 unit can be compared with the other two O-1107/SRC-16 units to determine the most stable of the three units. The O-1107/SRC-16 that provides the most stable 100-kc output is selected as the frequency standard for the Radio Set AN/SRC-23(V) system.

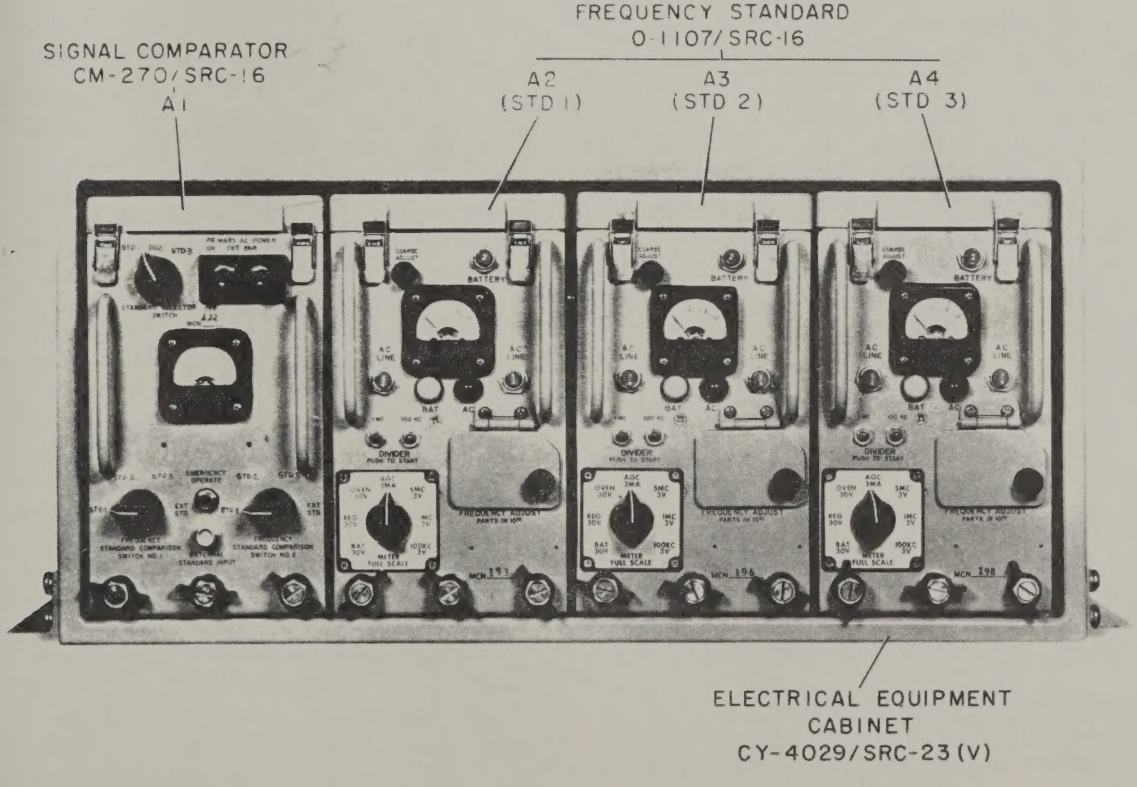


Figure 1-2. Frequency Standard Group OA-4792/SRC-23(V), Location of Major Assemblies

This selection is made by positioning the STANDARD SELECTOR SWITCH on the signal comparator. The CY-4029/SRC-23(V) cabinet provides the unit-to-unit wiring necessary to implement the operation of the signal comparator and the associated frequency standards.

1-4. REFERENCE DATA.

Input voltage	115 volts ±10%, 400 cps ±5%, single phase.
Power consumption	115 watts maximum (operating).
Size	23-3/4 inches wide, 24 inches deep, and 9-7/8 inches high.
Weight	99 pounds (complete).
Ambient temperature	0° to 50°C (32° to 122°F) (operating); -62° to 75°C (-92° to 167°F) (non-operating).
Ambient humidity	0 to 95 percent relative humidity.
Vibration	Meets type I vibration requirements of MIL-STD-167.
Shock	Meets Class B, type II shock requirements of MIL-S-901B.

1-5. EQUIPMENT SIMILARITIES.

Signal Comparator CM-270/SRC-16 and Frequency Standard O-1107/SRC-16 are also used in Communications Central AN/SRC-16 and Data Communication Group AN/TYA-19. All of the signal comparator units and frequency standards are interchangeable. The signal comparators are identical, and the frequency standards are identical with the exception of front panel markings. However, these units are organized into Frequency Standard Group OA-4792/SRC-23(V) and housed in the CY-4029/SRC-23(V) cabinet only in the Radio Set AN/SRC-23(V) system.

SECTION 2

INSTALLATION

2-1. REFERENCE.

Installation data for Frequency Standard Group OA-4792/SRC-23(V) is provided in chapter A, section 2 (volume 1).

SECTION 3

OPERATION

3-1. REFERENCE.

Frequency Standard Group OA-4792/SRC-23(V) operating procedures are described in system chapter A, section 3. The system operating procedures are bound separately as volume 2 of the technical manual.

SECTION 4

TROUBLESHOOTING

4-1. LOGICAL TROUBLESHOOTING.

Frequency Standard Group OA-4792/SRC-23(V) consists of four modules (a signal comparator and three frequency standards) housed in Electrical Equipment Cabinet CY-4029/SRC-23(V) which provides the unit-to-unit wiring necessary to implement the operation of the four modules. Therefore, the interconnection circuitry on the cabinet should be fault-analyzed before the signal comparator or frequency standards are fault-analyzed. Figure 5-3 is provided as an aid in testing the cabinet circuitry. Troubleshooting of Signal Comparator CM-270/SRC-16 is described in chapter M, and troubleshooting of Frequency Standard O-1107/SRC-16 is described in chapter L.

Troubleshooting for Frequency Standard Group OA-4792/SRC-23(V) should be based on the six steps of logic troubleshooting. These six steps are as follows:

a. SYMPTOM RECOGNITION. - This is the first step in the troubleshooting procedure. All equipment troubles are not the direct result of component failure. Therefore, a trouble in an equipment is not always easy to recognize, since all conditions of less than peak performance are not always apparent. This type of equipment trouble is usually discovered while accomplishing preventive maintenance procedures, such as the POMSEE checks. It is important that the not so apparent troubles, as well as the apparent troubles, be recognized.

b. SYMPTOM ELABORATION. - After an equipment trouble has been recognized, all the available aids designed into the equipment should be used to further elaborate the original trouble symptom. Use of equipment front panel controls and other built-in indicating or testing aids should provide a better identification of the original trouble symptom. Checking or otherwise manipulating the operating controls also may eliminate the trouble.

c. LISTING PROBABLE FAULTY FUNCTION. - The next logical step in troubleshooting is to formulate a number of educated guesses as to the cause and likely location (functional section) of the trouble. The educated guesses are mental decisions which are based on knowledge of the equipment operation, a full identification of the trouble symptom, and information supplied by the technical manual. The overall equipment functional discussion and block diagram should be referred to when selecting possible faulty functional sections.

d. LOCALIZING THE FAULTY FUNCTION. - For the greatest efficiency in localizing trouble, the functional sections which have been selected by the educated-guess method should be tested in the order that will require the least amount of time to find the faulty section. This requires a mental selection to determine which section to test first, i.e., quick sensory checks to eliminate possible trouble. The selection should be based on two factors: the validity of the educated guesses and the difficulties in making the necessary tests to check the functional section. Waveforms or other pertinent indications are included at significant checkpoints on servicing block diagrams to serve as aids in isolating the faulty section. Also, the test data supplied to augment the functional description and servicing block diagram of a functional section provides such information as pertinent control settings, critical adjustments, test equipment lists, and other necessary information which will aid in testing the functional section.

e. LOCALIZING TROUBLE TO CIRCUIT. - After the faulty functional section has been isolated, it should be replaced by a workable spare. Troubleshooting and repair of the functional sections are explained in the Technical Manual for Electronic Circuit Plug-in Test Set AN/URM-159.

f. FAILURE ANALYSIS. - After the trouble has been located and corrected, review the steps previously taken and decide why the trouble affected the equipment in the manner it did. This step is taken to determine if other circuit elements were responsible for the malfunction.

4-2. FUNCTIONAL DESCRIPTION.

Refer to the interconnection diagram shown in figure 5-3. Frequency Standard Group OA-4792/SRC-23(V) consists of a cabinet containing four assemblies: Signal Comparator CM-270/SRC-16 (assembly A1) and three Frequency Standards O-1107/SRC-16 (assemblies A2 through A4.) These assemblies are housed in Electrical Equipment Cabinet CY-4029/SRC-23(V). Each frequency standard provides a 100-kc signal. The signal comparator compares four 100-kc inputs (two at a time); these four inputs consist of three O-1107/SRC-16 frequency standard signals and one external frequency standard signal. Signal comparison is accurate to 1 part in 10^9 and is enabled by the two signal comparator FREQUENCY STANDARD COMPARISON SWITCH selectors. The O-1107/SRC-16 which provides the most stable 100-kc output is selected as the frequency standard for the Radio Set AN/SRC-23(V). This selection is made by positioning the STANDARD SELECTOR SWITCH on the signal comparator.

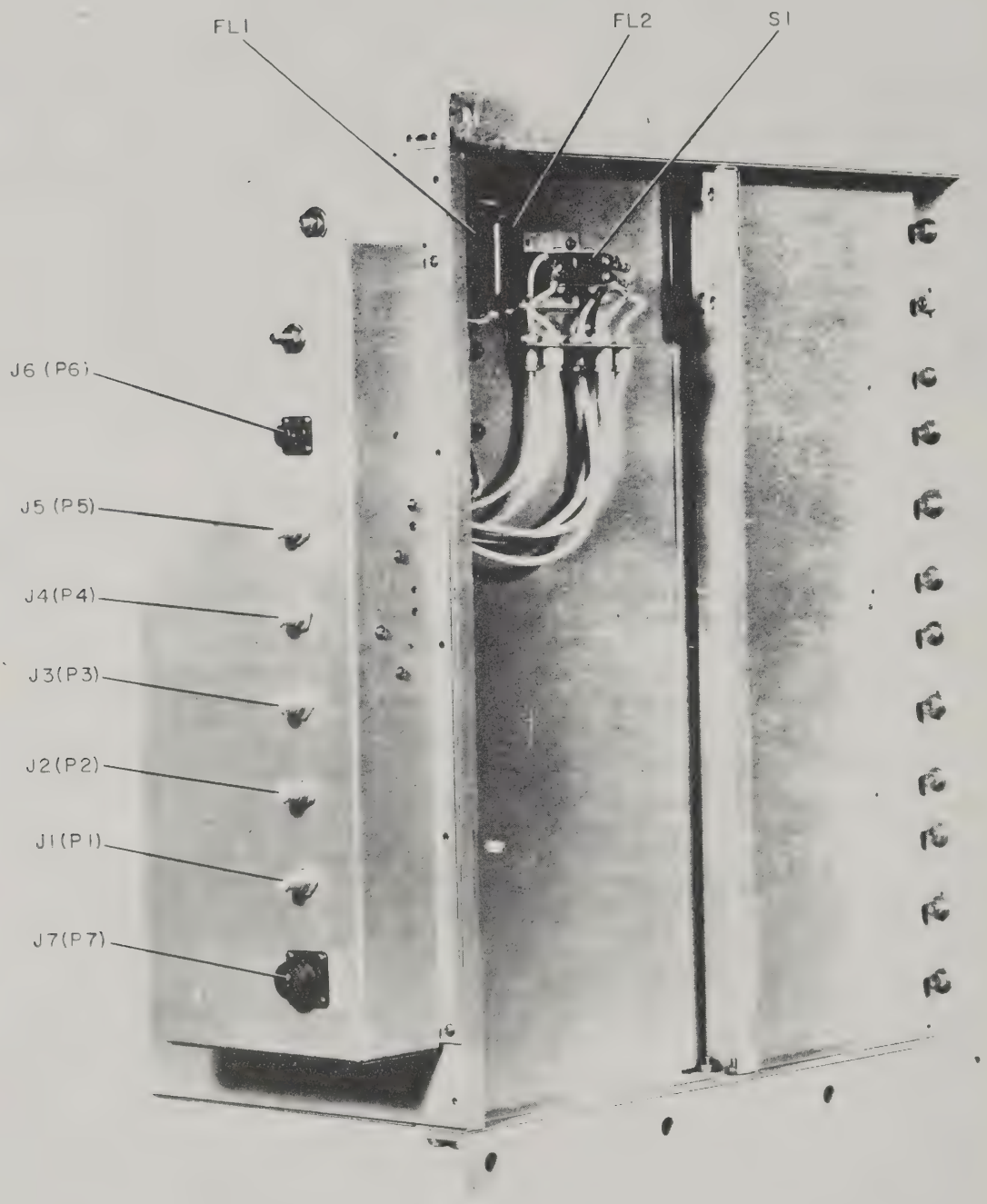
The frequency standard signal selected by the STANDARD SELECTOR SWITCH on the signal comparator is applied to Radio Set AN/SRC-23(V) from signal comparator output connector J8-8 via cabinet connector J5 and from signal comparator output connector J8-10 via cabinet connector J4. This frequency standard signal is applied through radio frequency isolation amplifier assembly A2 of the signal comparator. The frequency standard signal

is also applied through radio frequency isolation amplifier assembly A4 of the signal comparator. This assembly generates two frequency standard output signals called auxiliary outputs. These auxiliary outputs are applied to Radio Set AN/SRC-23(V) from signal comparator output connector J12 via cabinet connector J3 and from signal comparator output J-11 via cabinet connector J2. If radio frequency isolation amplifier assembly A2 (of the signal comparator) fails, the frequency standard signal normally sent through cabinet connectors J4 and J5 are disconnected, and the auxiliary frequency standard signal is switched from cabinet connectors J2 and J3 to cabinet connectors J4 and J5.

If the signal comparator is removed from the cabinet, all signal comparator connections are broken. However, removal of the signal comparator causes cabinet switch S12 to close. With switch S12 closed, frequency standard module A4 is connected to cabinet connectors J4 and J5. Thus, frequency standard module A4 supplies the frequency standard signal to the AN/SRC-23(V) system when the signal comparator is removed from the cabinet.

The 115-vac, 400-cps, single-phase power is applied to the power inputs of the signal comparator and to the three frequency standards through cabinet input connectors J7-A and J7-B. The power coming into the cabinet through J7-A is filtered by filter FL2, and the power coming into the cabinet through J7-B is filtered by filter FL1.

An alarm line is connected from signal comparator connector J8-2 to cabinet connector J6-A. This alarm line is not used in the Radio Set AN/SRC-23(V) system. The signal comparator holds a ground on this alarm line when the signal comparator is in its normal operating condition. If radio frequency isolation amplifier assembly A2 of the signal comparator fails, the alarm line ground will be removed at the same time that the auxiliary frequency standard signal is applied to cabinet connectors J4 and J5.



NOTE: EACH MATING-CONNECTOR SYMBOL IS SHOWN IN PARENTHESIS NEXT TO ITS CORRESPONDING CABINET-CONNECTOR SYMBOL

Figure 5-1. Electrical Equipment Cabinet CY-4029/SRC-23(V), Parts Location

SECTION 5

MAINTENANCE

5-1. GENERAL.

The maintenance procedures for Frequency Standard O-1107/SRC-16 are listed in chapter L, section 5, and the maintenance procedures for Signal Comparator CM-270/SRC-16 are listed in chapter M, section 5. No special procedures are required for Electrical Equipment Cabinet CY-4029/SRC-23(V).

5-2. REMOVAL OF ASSEMBLIES FROM CABINET.

The signal comparator and frequency standards are removed from the cabinet by loosening wingnuts on two outside collet fasteners on the unit, turning wingnut on center extractor screw of unit counter-clockwise to loosen, and pulling unit out of cabinet. Installation is the opposite of removal. When a unit is pulled from the cabinet, all power and signal inputs and outputs are disconnected from the unit at the connectors at the rear of the unit. However, when a frequency standard is removed, an auxiliary power supply within the unit will provide power to the unit for up to 2 hours.

5-3. PARTS LOCATION ILLUSTRATIONS.

Refer to figures 5-1 and 5-2 for parts identification illustrations.

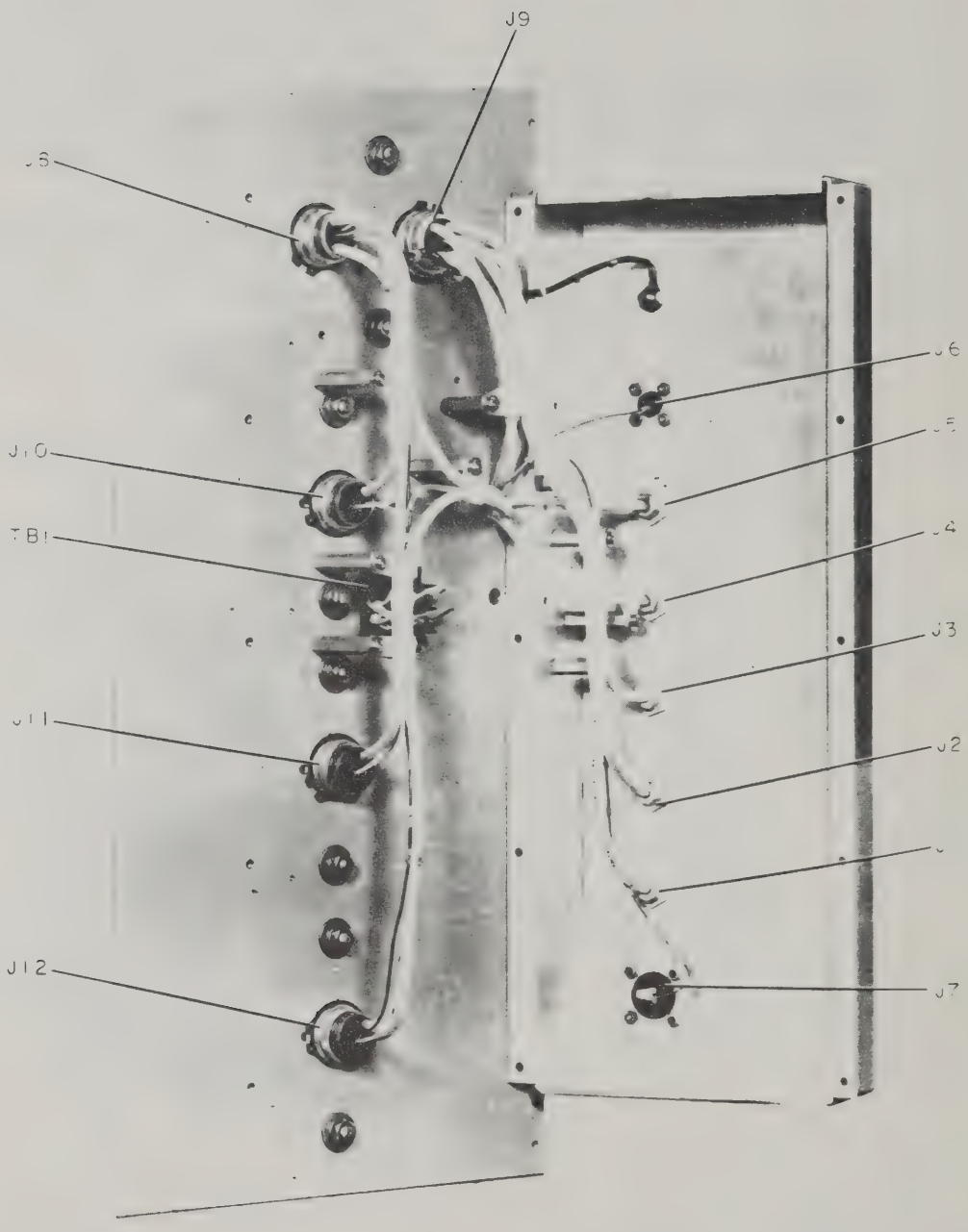
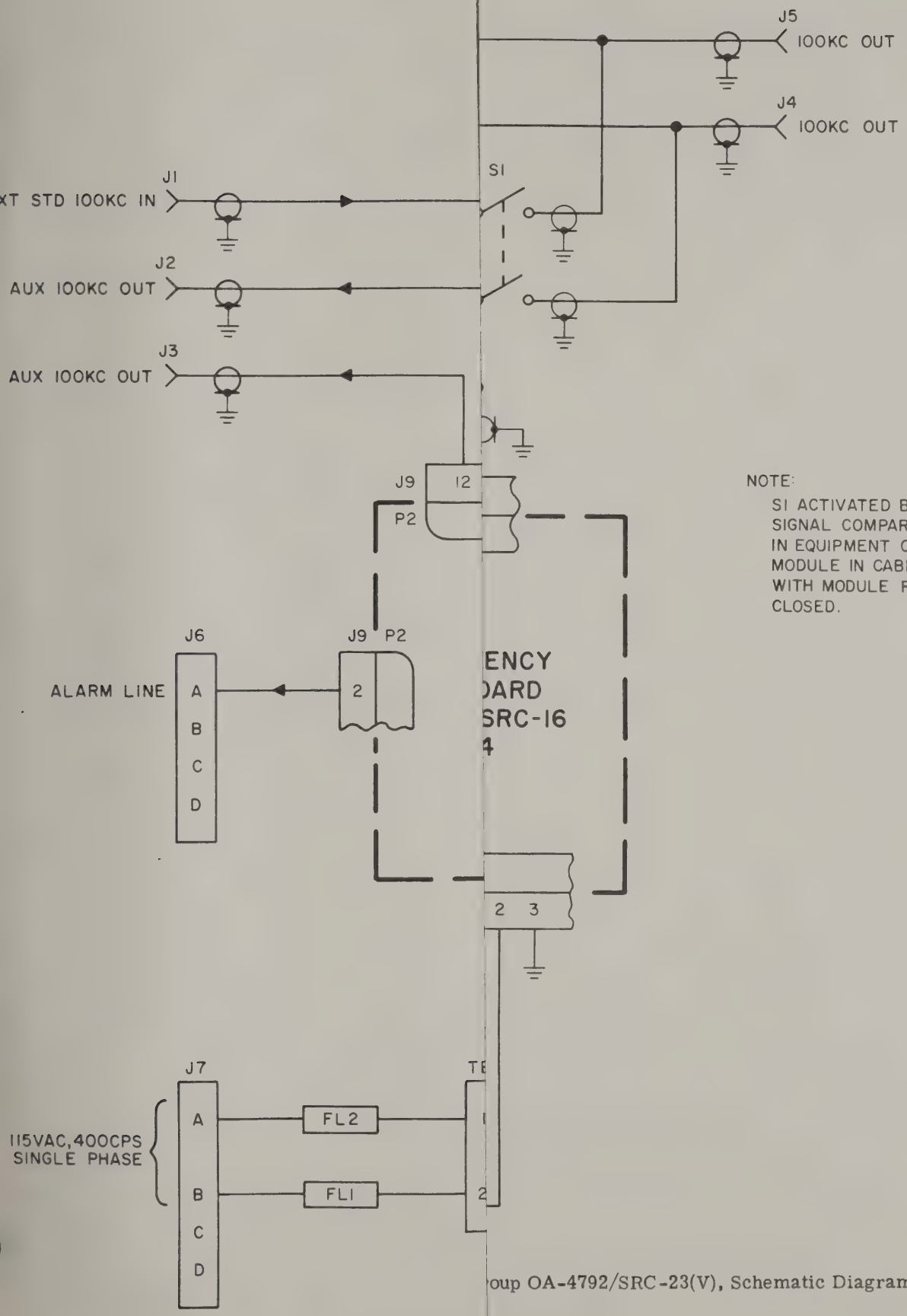


Figure 5-2. Electrical Equipment Cabinet CY-4029/SRC-23(V), Parts Location



oup OA-4792/SRC-23(V), Schematic Diagram

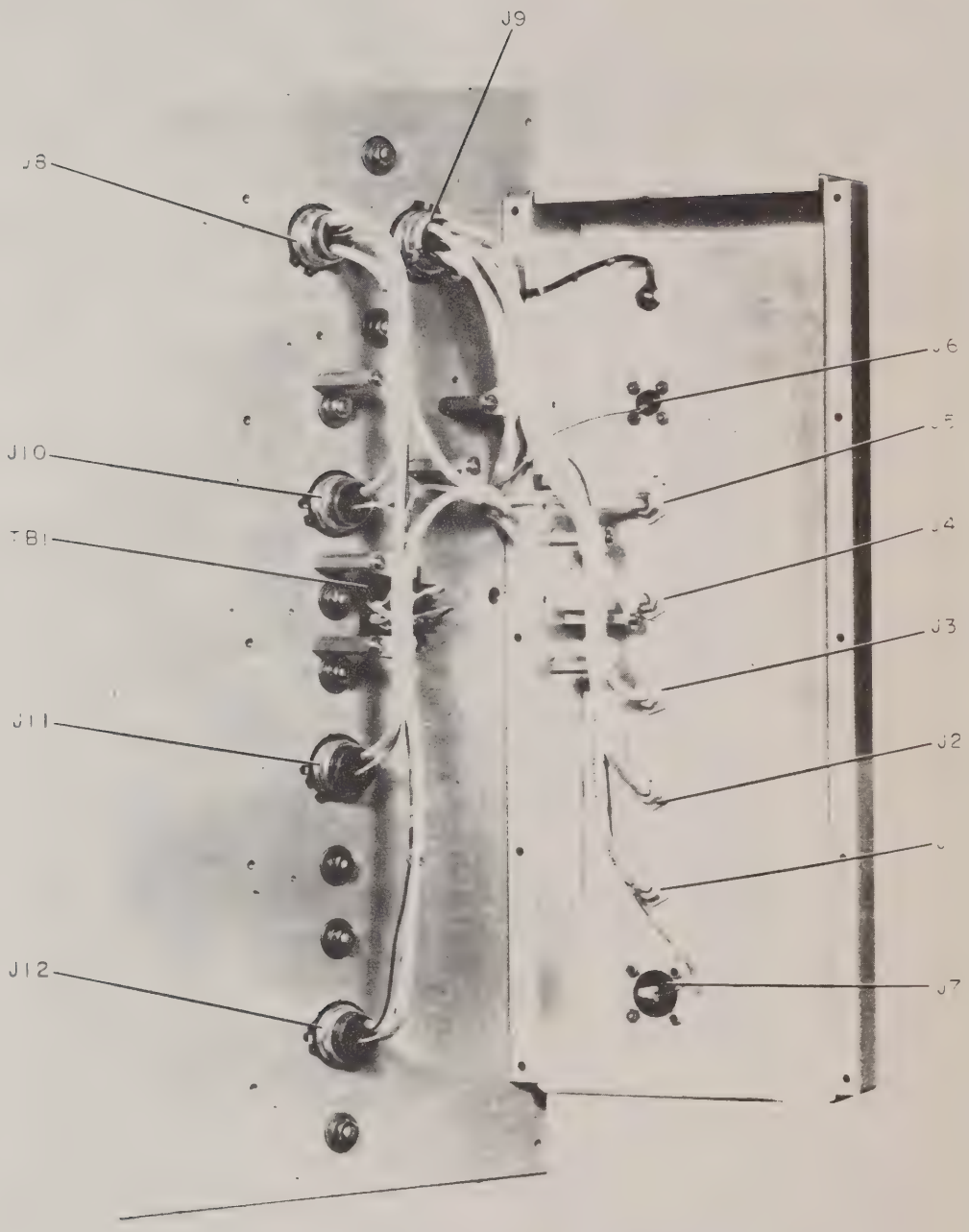
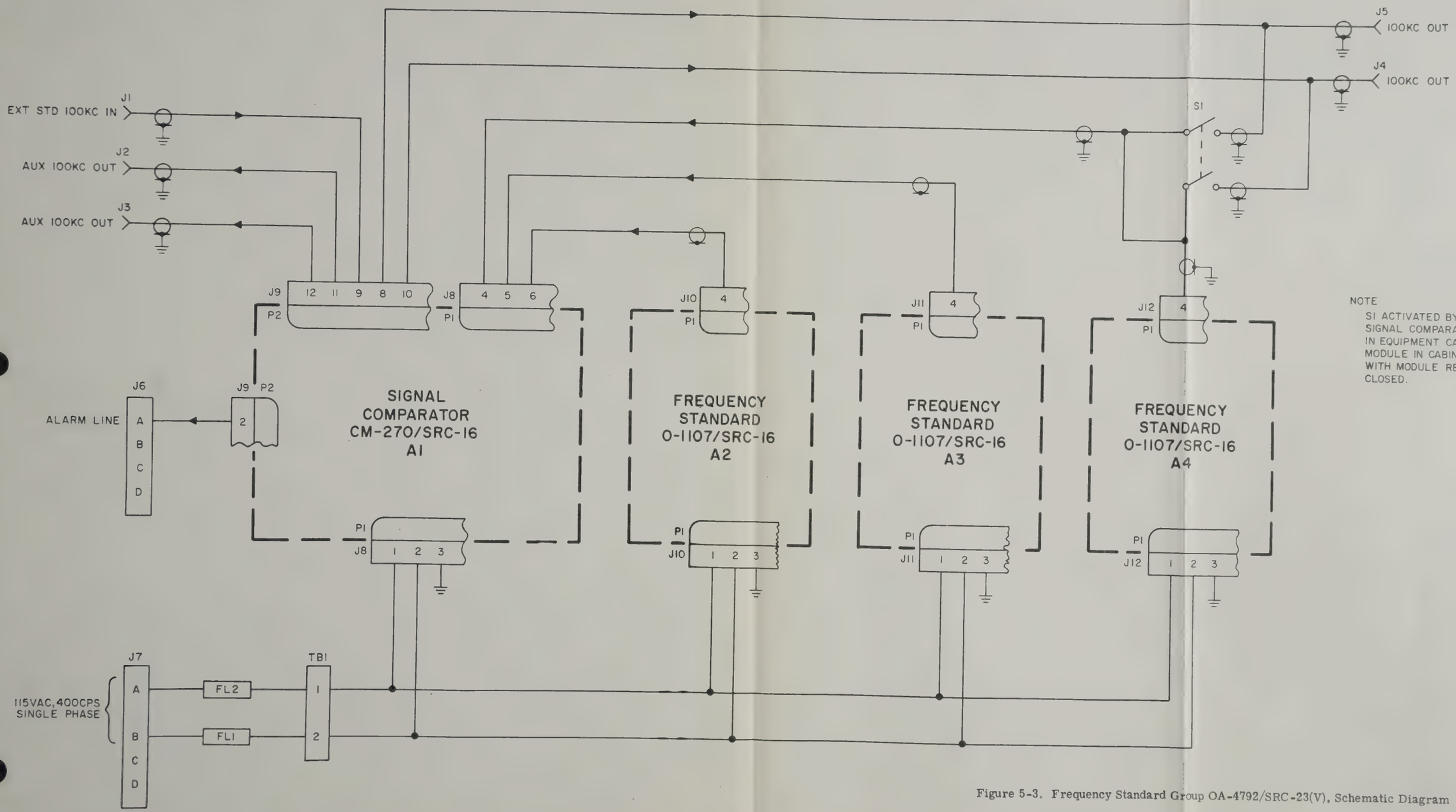


Figure 5-2. Electrical Equipment Cabinet CY-4029/SRC-23(V), Parts Location



NOTE

S1 ACTIVATED BY POSITION OF SIGNAL COMPARATOR MODULE IN EQUIPMENT CABINET. WITH MODULE IN CABINET, S1 IS OPEN WITH MODULE REMOVED, S1 IS CLOSED.

Figure 5-3. Frequency Standard Group OA-4792/SRC-23(V), Schematic Diagram

SECTION 6

PARTS LIST

6-1. REFERENCE.

Refer to chapter O, volume 5

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VOLUME 4

TECHNICAL MANUAL

for

RADIO SET AN/SRC-23(V)

CHAPTER L
FREQUENCY STANDARD
O-1107/SRC-16

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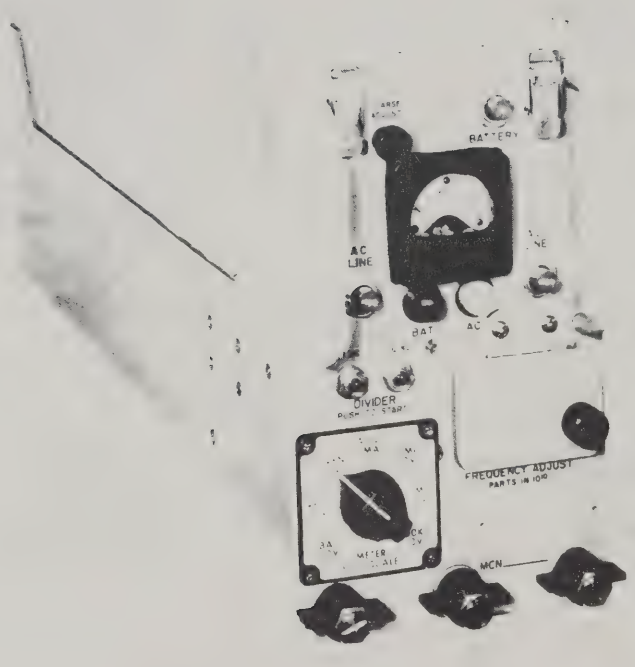


Figure 1-1. Frequency Standard O-1107, SRC-16

SECTION 1

GENERAL INFORMATION

1-1. SCOPE.

This chapter describes Frequency Standard O-1107/SRC-16 which is part of Radio Set AN/SRC-23(V). The chapter includes general information, troubleshooting procedures, maintenance procedures, and operating procedures. Additional operating procedures are contained in chapter A, section 3 (volume 2). Installation procedures are contained in chapter A, section 2 (volume 1). Parts list information is contained in chapter O, sections 1 through 3 (volume 5).

This chapter is in effect upon receipt. Extracts may be made to facilitate the preparation of other Department of Defense Publications.

1-2. RELATED PUBLICATIONS.

Troubleshooting and adjustment procedures for the 1-mc divider assembly and the 100-kc divider assembly are provided in the Technical Manual for Electronic Circuit Plug-in Unit Test Set AN/URM-159. Preventive maintenance schedules and procedures are contained in the Maintenance Standards Book for Radio Set AN/SRC-23(V), NavShips 0967-163-9070.

1-3. GENERAL DESCRIPTION.

Frequency Standard O-1107/SRC-16 (frequency standard) (figure 1-1) is a transistorized primary frequency standard which provides unmodulated sine-wave outputs of 100 kc and 1 mc. The frequency accuracy is better than 1 part in 100 million. The three frequency standards are connected to the system receivers and transmitters through Signal Comparator CM-270/SRC-16. The signal comparator is used to monitor the three frequency standards and select one of them as the primary frequency standard for the system. The frequency standard ordinarily receives its power from a 115-volt, 400-cps, single-phase power source. If this power source fails, two 12-volt, series-connected internal batteries are automatically switched to the frequency standard power input. These batteries will maintain the O-1107/SRC-16 frequency stability for at least 2 hours. The batteries are automatically recharged by the 115-volt, 400-cps, single-phase source. In addition, the frequency standard can receive its power from an external 24-volt battery power source. The frequency standard consists of five electrical assemblies: oscillator assembly A1, 1-mc divider assembly A2, 100-kc divider A3, regulator assembly A4, and electrical equipment chassis assembly A5. Assemblies A1 through A4 are modular plug-in assemblies which can be easily removed and replaced on the chassis. The frequency standard is intended for installation in a cabinet which provides power and signal connections.

At some AN/SRC-23(V) installations, the O-1107/SRC-16 may be supplied as part of Frequency Standard Group OA-4792/SRC-23(V) and installed in Electrical Equipment Cabinet CY-4029/SRC-23(V), as shown in figure 1-1 of chapter K. At other AN/SRC-23(V) installations, a single O-1107/SRC-16 may be supplied in Electrical Equipment Cabinet CY-4932/SRC-23(V) as part of Receiver-Transmitter Group OA-8012/SRC-23(V), as shown in figure 1-1 of chapter A.

1-4. REFERENCE DATA.

Output frequencies	1 mc, 100 kc.
Output impedance	50 ohms.
Output voltage	1 volt.
Duty cycle	Continuous.
Frequency stability aging rate	Less than 1 part in 10^8 for 30 days (0.001 cps at 100 kc).
Temperature variation	Less than ±4 parts in 10^{11} per degree centigrade (0.000004 cps at 100 kc).
Reset accuracy	Better than ±5 parts in 10^{11} (0.000005 cps at 100 kc).
Frequency change with shock	Less than 1 part in 10^8 (0.001 cps at 100 kc).
Coarse frequency control	Allows variation of frequency by ±1 part per million ±0.1 cps at 100 kc).
Fine frequency control	Allows variation of frequency in incremental steps of 1 part in 10 billion ±20 percent (0.00001 cps at 100 kc) for a total of 500 parts in 10 billion (0.005 cps at 100 kc).
Harmonic distortion	40 db below rated output.
Spurious output	80 db below rated output.

Input voltage	115 volts, single phase, 400 cps.
Input power	Not greater than 25 watts.
Standby power	Automatically connected internal batteries capable of providing 2 hours operation (provisions for connecting an external 24-volt battery).
Ambient temperature	0° to 50°C (32° to 122°F).
Ambient humidity	Up to 100 percent relative humidity.
Size	4-7/8 inches wide, 8-3/4 inches high, 19 inches long, excluding extractor screws and guide pins.
Weight	21 pounds.
Mounting	Shelf-mounted in appropriate cabinet with all mounting devices accessible from front panel.

1-5. EQUIPMENT SIMILARITIES.

Frequency Standard O-1107/SRC-16 is interchangeable with the frequency standard used in Communications Central AN/SRC-16 and the frequency standard used in Data Communication Group AN/TYA-19.

SECTION 2

INSTALLATION

2-1. REFERENCE.

Frequency Standard O-1107/SRC-16 is supplied as part of Receiver-Transmitter Group OA-8012/SRC-23(V) or Frequency Standard Group OA-4792/SRC-23(V). Installation data for these equipments is provided in chapter A, section 2.

SECTION 3

OPERATION

3-1. FUNCTIONAL OPERATION.

The frequency standard is a primary standard with unmodulated sine-wave outputs of 1 mc and 100 kc. A 5-mc signal is generated by a temperature-stabilized, amplitude-controlled crystal oscillator. The output of the 5-mc crystal oscillator is divided by 5 in the 1-mc divider assembly. The 1-mc signal is divided by 10 to produce an output of 100 kc. The divider circuits have a lockout feature which disables them whenever the divider input signals are temporarily interrupted. Operation of the dividers can be restored by pressing the 1 MC DIVIDER PUSH TO START and the 100 KC DIVIDER PUSH TO START pushbuttons in that order.

A test meter selector switch, METER FULL SCALE, is provided to monitor seven important operating voltages within the frequency standard. Indicator lamps are provided to indicate the application of power, and power input is controlled by circuit breakers. Refer to figure 3-1. A frequency adjustment is provided to adjust the 5-mc crystal oscillator frequency in steps of 1 part in 10 billion to compensate for crystal aging. Each graduation on the FREQUENCY ADJUST PARTS IN 10^{10} control results in a change of 0.00001 cps in the 100-kc output.

3-2. DESCRIPTION OF CONTROLS AND INDICATORS.

Table 3-1 lists the functions of the frequency standard controls and indicators. Refer to figure 3-1.

TABLE 3-1. CONTROLS AND INDICATORS

CONTROL OR INDICATOR	FUNCTION
AC LINE circuit breakers	Protect 115-volt ac primary power supply against overload.
BATTERY circuit breaker	Protects both the internal and external standby battery sources.
AC and BAT indicators	AC and BAT indicator lamps light when ac power is applied. BAT indicator lamp lights when unit is operating on battery power.
COARSE ADJUST control	Provides coarse frequency adjustment.
1 MC DIVIDER PUSH TO START pushbutton	Restores operation of the 1-mc divider assembly after a fault.
100 KC DIVIDER PUSH TO START pushbutton	Restores operation of the 100-kc divider assembly after a fault.

TABLE 3-1. (Continued)

CONTROL OR INDICATOR	FUNCTION
Front panel test meter	Monitors the function selected by the METER FULL SCALE selector.
METER FULL SCALE selector	
BAT 30V	Connects the meter to the 30-volt battery charging circuit.
REG 30V	Connects the meter to the 15-volt regulated supply voltage.
OVEN 30V	Connects the meter to the output of the oven-driver amplifier (10 volts after warmup).
AGC 3MA	Connects the meter to the 5-mc crystal oscillator agc line (1 ma).
5MC 3V	Connects the meter to the 5-mc output of the oscillator assembly (1.0 volt to 1.6 volts).
1MC 3V	Connects the meter to the output of the 1-mc divider assembly (1.0 volt to 2.0 volts).
100KC 3V	Connects the meter to the output of the 100-kc frequency divider subassembly (1.0 volt to 1.5 volts).
Unmarked position	Disconnects the meter from the circuit.
FREQUENCY ADJUST PARTS IN 10^{10}	Located under a cover on the front panel; this adjustment is made to compensate for crystal aging. Each graduation change in the dial reading results in a change of 1 part in 10 billion ±20 percent (0.00001 cps at 100 kc).
Frequency adjustment lock	Locks the FREQUENCY ADJUST PARTS IN 10^{10} control.

3-3. OPERATING PROCEDURES.

Once the frequency standard is placed in operation, the only operating checks required are (1) periodic checks to see that primary power is applied to the unit, (2) periodic checks on the metered functions of the unit, (3) starting of the frequency dividers in the event of automatic lockout resulting from a fault, and (4) periodic compensation for aging of the oscillator crystal (refer to section 5).

a. PRIMARY POWER CHECK. - Power must be applied to the frequency standard at all times to ensure frequency reliability and stability. To ensure an uninterrupted source of power, make periodic checks to see that the AC and BAT indicator lamps are lit. If the AC indicator lamp is not lit, the frequency standard is operating on battery power and is limited to 2 hours of continuous operation. See emergency operating procedure of paragraph 3-4.

b. MONITORING OF METERED FUNCTIONS. - Refer to the frequency standard preventive maintenance procedures described in the Maintenance Standards Book for Radio Set AN/SRC-23(V). Normal test meter indications are listed in table 3-2.

TABLE 3-2. NORMAL TEST METER INDICATIONS

METER FULL SCALE POSITION	NORMAL INDICATION
BAT 30V	30.0 volts.
REG 30V	15 volts.
OVEN 30V	10 volts operating, 23 to 28 volts during warmup.
AGC 3MA	1.0 ma.
5MC 3V	1 volt minimum.
1MC 3V	1 volt minimum.
100KC 3V	1 volt minimum.

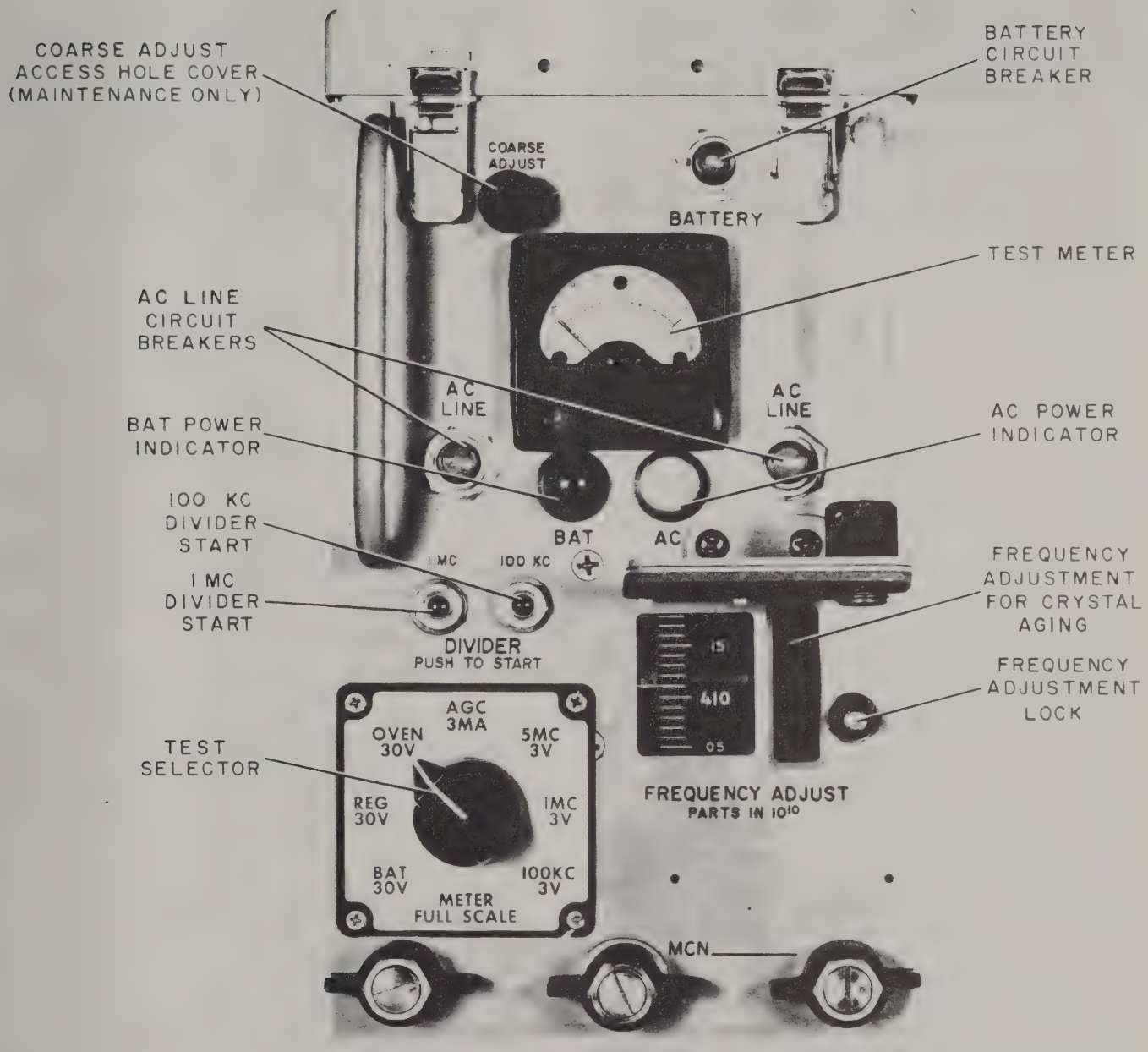


Figure 3-1. Frequency Standard O-1107/SRC-16, Controls and Indicators

c. STARTING FREQUENCY DIVIDERS. - The 1-mc and 100-kc frequency divider circuits each have a lockout feature which automatically disables the divider circuit whenever the divider input signal is interrupted. To start the 100-kc frequency divider, press the 100 KC DIVIDER PUSH TO START pushbutton. Lockout of the 1-mc frequency divider also results in lockout of the 100-kc frequency divider. When this happens, first press the 1 MC DIVIDER PUSH TO START pushbutton; then press the 100 KC DIVIDER PUSH TO START pushbutton. Operation of the frequency dividers can be checked by setting the METER FULL SCALE switch to 1MC 3V and 100KC 3V. Check for normal meter reading of at least 1 volt.

3-4. EMERGENCY OPERATION.

If the 115-volt power to the frequency standard is interrupted for any reason, the internal standby battery will supply power to the unit for at least 2 hours. This standby period can be extended by connecting an external 24-volt standby battery to the unit. In the event of a 115-volt power failure, check the two AC LINE circuit breakers and cabinet supply. If operating the circuit breakers does not restore primary ac power or circuit breakers do not remain closed, note time of power failure.

CAUTION

If ac power interruption exceeds the time limit of the standby battery life, a relay in the frequency standard will disconnect the battery, and the BAT indicator will go out. When this happens, all power is removed from the frequency standard, and frequency stability will be destroyed. It will then be necessary to repeat the alignment procedure of paragraph 5-2a before returning the unit to service.

SECTION 4

TROUBLESHOOTING

4-1. LOGIC TROUBLESHOOTING.

The frequency standard is a modularized unit and, therefore, must be fault-analyzed on the module level and then on the circuit level. Before any internal tests are performed, however, perform the primary power check and meter monitoring procedures described in paragraphs 3-3a and 3-3b. Data from these checks should be recorded to provide a suitable basis for the troubleshooting procedure. It should be noted that the 1-mc divider and 100-kc divider assemblies may be tested using the Electronic Circuit Plug-in Unit Test Set AN/URM-159 if the trouble is isolated to one of these modules. The servicing block diagram, figure 4-1, and schematic diagram, figure 5-16, are provided as aids for module and circuit testing. All values are nominal to within ±15 percent.

Troubleshooting for this frequency standard should be based on the six steps of logic troubleshooting. These six steps are as follows:

a. SYMPTOM RECOGNITION. - This is the first step in the troubleshooting procedure. All equipment troubles are not the direct result of component failure. Therefore, a trouble in an equipment is not always easy to recognize, since all conditions of less than peak performance are not always apparent This type of equipment trouble is usually discovered while accomplishing preventive maintenance procedures, such as the POMSEE checks. It is important that the not so apparent troubles, as well as the apparent troubles, be recognized.

b. SYMPTOM ELABORATION. - After an equipment trouble has been recognized, all the available aids designed into the equipment should be used to further elaborate the original trouble symptom. Use of equipment front panel controls and other built-in indicating or testing aids should provide a better identification of the original trouble symptom. Checking or otherwise manipulating the operating controls also may eliminate the trouble.

c. LISTING PROBABLE FAULTY FUNCTION. - The next logical step in troubleshooting is to formulate a number of educated guesses as to the cause and likely location (functional section) of the trouble. The educated guesses are mental decisions which are based on knowledge of the equipment operation, a full identification of the trouble symptom, and information supplied by the technical manual. The overall equipment functional discussion and block diagram should be referred to when selecting possible faulty functional sections.

d. LOCALIZING THE FAULTY FUNCTION. - For the greatest efficiency in localizing trouble, the functional sections which have been selected by the educated-guess method should be tested in the order that will require the least amount of time to find the faulty section. This requires a mental selection to determine which section to test first, i.e., quick sensory checks to eliminate possible trouble. The selection should be based on two factors: the validity of the educated guesses and the difficulties in making the necessary tests to check the functional section. Waveforms or other pertinent indications are included at significant checkpoints on servicing block diagrams to serve as aids in isolating the faulty section. Also, the test data supplied to augment the functional description and servicing block diagram of a functional section provides such information as pertinent control settings, critical adjustments, test equipment lists, and other necessary information which will aid in testing the functional section.

e. LOCALIZING TROUBLE TO CIRCUIT. - After the faulty functional section has been isolated, it should be replaced by a workable spare. Troubleshooting and repair of the functional sections are explained in the Technical Manual for Electronic Circuit Plug-in Test Set AN/URM-159.

f. FAILURE ANALYSIS. - After the trouble has been located and corrected, review the steps previously taken and decide why the trouble affected the equipment in the manner it did. This step is taken to determine if other circuit elements were responsible for the malfunction.

4-2. OVERALL FUNCTIONAL DESCRIPTION.

The frequency standard is a primary standard with unmodulated sine-wave outputs of 1 mc and 100 kc, having a frequency accuracy of better than 1 part in 100 million. Figure 4-1 is a servicing block diagram of the frequency standard. Figure 5-16 is an overall schematic diagram of the unit. A 5-mc signal is generated by a temperature-stabilized, amplitude-controlled crystal oscillator. The 5-mc signal is applied to the 1-mc frequency divider which divides it by 5, providing an output of 1 mc. The 1-mc signal is applied to the 100-kc frequency divider where it is divided by 10 to produce an output frequency of 100 kc, which is accurate to ±0.001 cps. Both dividers have a lockout feature which disables them in the event their input signal is interrupted.

The frequency standard is powered from a 115-volt, 400-cps, single-phase source. An internal standby battery provides 2 hours of continuous operation in the event primary power fails. Standby batteries are charged when the frequency standard is powered from the primary source. An external battery can be connected to lengthen the period of battery operation if necessary, but it is not possible to charge the external batteries from the frequency standard.

4-3. OSCILLATOR ASSEMBLY A1.

a. FUNCTIONAL DESCRIPTION.

(Refer to figure 5-16.)

(1) OSCILLATOR CIRCUIT. - A 5-mc signal is generated by oscillator transistor A1Q1 and a 5-mc,

fifth-overtone crystal connected in the base collector circuit. The crystal is operated in series resonance with inductor A1L2, capacitor A1C4, COARSE ADJUST capacitor A1C3, and FREQUENCY ADJUST PARTS IN 10^{10} inductor L1. Oscillation at the fundamental or third-overtone frequencies is prevented by a parallel resonant circuit composed of inductor A1L1 and capacitor A1C1 which is tuned to 3.5 mc. The output of the oscillator is direct-coupled to the first of three amplifier stages, transistor A1Q2.

(2) 5-MC AMPLIFIERS CIRCUIT. - The output of the 5-mc crystal oscillator is coupled to three low-gain buffer amplifier transistors A1Q2, A1Q3, and A1Q4. These stages have voltage gains of 10 to 20 and are tuned with low-Q tank circuits to provide stable, parasitic-free operation without neutralizing capacitors. The output of the third buffer amplifier stage is coupled to crystal current limiter transistor A1Q5 and 5-mc driver amplifier transistor A1Q6. Driver amplifier transistor A1Q6 is transformer coupled to a push-pull output power amplifier stage composed of transistors A1Q7 and A1Q8. The output of the power amplifier is transformer coupled to the input of 1-mc frequency divider subassembly A2. A second tap on the output transformer provides an output to meter rectifier A1CR2.

(3) CRYSTAL CURRENT LIMITER CIRCUIT. - Crystal current limiter transistor A1Q5 is normally cut off. When the signal output of buffer amplifier transistor A1Q3 exceeds a predetermined level, rectifier A1CR1 applies a bias to transistor A1Q5 which drives the transistor into conduction. This increases the voltage drop across resistor A1R18 and results in reduced output from the oscillator. The voltage developed across resistor A1R17 is fed to the AGC 3MA position of the METER FULL SCALE switch and is applied to test meter M1 as an indication of agc action.

(4) OSCILLATOR OVEN CIRCUIT. - A 2-stage oven is used to provide temperature stability for the 5-mc crystal oscillator. The crystal and associated reactive components are enclosed in the inner oven. The remainder of the oscillator circuit and the first buffer amplifier transistor are enclosed in the outer oven. The oven temperature is maintained by an audio-frequency oscillator which furnishes power to oven heater windings A1HR1 and A1HR2. Heater winding A1HR1 is wound around the inner oven, and heater winding A1HR2 is wound around the outer oven. Oven input amplifier transistor A1Q9 contains the frequency determining elements in its collector circuit which cause the oscillation to occur at 5 kc. The output of A1Q9 is transformer coupled to oven driver transistor A1Q10, the output of which is transformer coupled to push-pull oven output amplifier transistors A1Q11 and A1Q12. Transformer A1T5 couples the audio signal to the oven heater windings. The windings in the inner oven, A1HR1, are wound so that they form a resistive bridge circuit. Each pair of two opposite bridge sides are wound with wire of a different temperature coefficient of resistance. Power is applied to the two horizontal connections of the bridge (connected to A1P3-A and A1P3-C). When power is initially applied to the bridge, the windings are not exactly 80 ohms as indicated. Instead, one opposite pair of windings will have a resistance somewhat lower than the other pair of windings. This causes an unbalance, and the bridge develops a voltage across the terminals connected to A1P3-B and A1P3-D. The voltage resulting from bridge unbalance results in a positive feedback condition which causes the oven amplifier to oscillate at a 5-kc rate. As the oven temperature rises, the resistances of the two sets of bridge windings become more nearly the same, and the signal voltage is reduced, thereby reducing the power applied to the oven heater windings. Eventually, equilibrium is reached, and power supplied by the oven amplifiers is just sufficient to maintain the bridge in a balanced condition. Resistor A1R40 is shunted across one of the windings to establish the oven temperature at which equilibrium is reached. This resistor is selected during manufacture and establishes the oven temperature for each individual crystal; it should not be changed or tampered with. Each crystal has a turning point temperature at which the rate change of frequency with respect to temperature change is zero. The crystals used in the frequency standard operate between 70° and 75°C (158° and 167°F).

b. TEST DATA.

(1) REFERENCE ILLUSTRATIONS.

(a) Servicing block diagram, figure 4-1.

(b) Schematic diagram, figure 5-16.

(c) Parts location illustrations, figures 5-5 through 5-10.

(2) CRITICAL ADJUSTMENTS. - Refer to the coarse frequency adjustment and crystal aging calibration procedures described in paragraph 5-2b.

(3) TEST INDICATIONS. - Use the front panel METER FULL SCALE test selector to check the oscillator assembly A1 circuits.

(a) Set test selector to 5MC 3V position. The meter should indicate 1.0 to 1.6 volts at the 5-mc output of oscillator assembly A1.

(b) Set test selector to AGC 3MA position. The meter should indicate 1.0-ma crystal current.

(c) Set test selector to OVEN 30V position. The meter should indicate 10 volts at the output of the crystal oven output amplifier, assuming steady state conditions after warmup.

(d) Test voltages at the input and output of oscillator assembly A1 stages are indicated on the schematic diagram, figure 5-16. Refer to the schematic diagram to isolate the cause of trouble to a particular stage or circuit.

4-4. 1-MC DIVIDER ASSEMBLY A2.

a. FUNCTIONAL DESCRIPTION.

(Refer to figure 5-16.)

(1) FREQUENCY DIVIDER CIRCUIT. - The 5-mc signal is amplified by buffer amplifier transistor A2Q1 and coupled to mixer transistor A2Q2. Mixer transistor A2Q2 amplifies the signal and feeds it to a tuned circuit composed of A2C5 and A2C8 and inductor A2L2. This is a high-Q circuit tuned to 1 mc. Noise inherent in the 5-mc signal is sufficient to ring the

tuned circuit at 1 mc, and this 1-mc voltage is applied to the base of x4 multiplier transistor A2Q3. The output of multiplier transistor A2Q3 is tuned to 4 mc, and this voltage is applied to the base of mixer transistor A2Q2. The net result of the mixing action is that mixer transistor A2Q2 has a 5-mc signal applied to its emitter and a 4-mc signal applied to its base. The 1-mc difference frequency appears in the tuned output of mixer transistor A2Q2.

(2) 1-MC AMPLIFIER CIRCUIT. - The 1-mc output of the frequency divider circuit is amplified to the desired output level by driver amplifier transistor A2Q5 and push-pull power amplifier transistors A2Q6 and A2Q7. The output transformer of the power amplifier stage supplies a 1-mc, 1-volt, 50-ohm signal to rear chassis connector P1-5. This output is used only for test purposes. A 1-mc signal also is routed to meter rectifier A2CR2 and supplies a rectified voltage to front panel test meter M1 for an indication of frequency divider operation. Another portion of the 1-mc signal is used to supply the 1-mc frequency divider lockout circuit and 100-kc divider assembly A3.

(3) LOCKOUT CIRCUIT. - The 1-mc lockout circuit disables the frequency divider circuit whenever the 5-mc signal input is interrupted. This is accomplished by controlling the emitter bias of mixer transistor A2Q2. During normal operation, a portion of the power amplifier output signal is rectified by diodes A2CR1 and A2CR3 and applied as bias to cut off lockout transistor A2Q4. When lockout transistor A2Q4 is cut off, normal operating bias is applied to the emitter of mixer transistor A2Q2 through resistor A2R5. If the 5-mc input signal is interrupted, the 1-mc output of the power amplifier is lost, lockout transistor A2Q4 conducts, and a cutoff bias is applied to the emitter of mixer transistor A2Q2. When the 5-mc signal is restored, mixer transistor A2Q2 remains cut off, because no 1-mc signal can be obtained to return the lockout transistor to normal cutoff operating condition. A ground is applied to the base of lockout transistor A2Q4 through resistor A2R11 when 1 MC DIVIDER PUSH TO START pushbutton S3 is pressed. This action returns the lockout circuit to normal operation.

b. TEST DATA.

(1) REFERENCE ILLUSTRATIONS.

(a) Servicing block diagram, figure 4-1.

(b) Schematic diagram, figure 5-16.

(c) Parts location illustrations, figures 5-11 and 5-12.

(2) TEST INDICATIONS. - Use the front panel METER FULL SCALE test selector to check the 1-mc divider assembly A2 output. Set test selector to 1MC 3V position. The meter should indicate 1.0 to 2.0 volts at the output.

(3) FAULT ISOLATION AND ADJUSTMENT PROCEDURE. - Refer to the Technical Manual for Electronic Circuit Plug-in Unit Test Set AN/URM-159.

4-5. 100-KC DIVIDER ASSEMBLY A3.

a. FUNCTIONAL DESCRIPTION. - Operation of the 100-kc divider is similar to the 1-mc frequency divider operation described in paragraph 4-4. This 100-kc divider assembly mixes the 1-mc output from the 1-mc divider with an internally generated 900-kc signal to obtain an output signal of 100 kc. The 100-kc lockout circuit operates the same as the 1-mc lockout circuit.

b. TEST DATA.

(1) REFERENCE ILLUSTRATIONS.

(a) Servicing block diagram, figure 4-1.

(b) Schematic diagram, figure 5-16.

(c) Parts location illustrations, figures 5-13 and 5-14.

(2) TEST INDICATIONS. - Use the front panel METER FULL SCALE test selector to check the 100-kc divider assembly A3 output. Set test selector to 100KC 3V position. The meter should indicate 1.0 to 2.0 volts at the output.

(3) FAULT ISOLATION AND ADJUSTMENT PROCEDURE. - Refer to the Technical Manual for Electronic Circuit Plug-in Unit Test Set AN/URM-159.

4-6. POWER SUPPLY CIRCUITS.

a. FUNCTIONAL DESCRIPTION.

(Refer to figure 5-16.)

(1) 30-VOLT POWER SUPPLY. - The 30-volt power supply converts 115-volt, 400-cps, single-phase primary power to regulated 30 volts dc which is used to operate the crystal oven amplifier, maintain a charge on the standby batteries, and supply power to the 15-volt regulator. The 115-volt input is applied to stepdown transformer A5T1 through power switch A5S1, AC LINE circuit breakers A5CB1 and A5CB2, and filters A5FL1 and A5FL2. Because power is applied to the unit at all times, switch S1 is not considered an operating control and is located under the top dust cover of the unit. The output of transformer A5T1 is fed through magnetic amplifier A5MR1 to full-wave rectifiers A4CR1 and A4CR2. The rectified output is applied to a bridge circuit, made up of resistors A4R1 through A4R4 and A4R11 and diodes A4CR3 through A4CR6. The bridge supplies a control current to magnetic amplifier A5MR1. The control current decreases the core saturation of the magnetic amplifier. As a result, the voltage applied to the rectifiers decreases. The bridge is adjusted by potentiometer A4R1 to provide a nominal rectifier output of 30 volts.

(2) REGULATOR ASSEMBLY A4. - The voltage regulator circuit provides two regulated 15-volt dc outputs. One is supplied directly from the regulator to the input amplifier of the crystal oven control circuit. The other output is filtered and supplied to the 5-mc crystal oscillator and both frequency divider circuits. Transistor A4Q1 is a series regulator and controls the output voltage level by changes in conductivity. Transistor A4Q2 is controlled by a bridge circuit, consisting of zener diodes A4CR7 through A4CR9 and resistors A4R9 and A4R10, and is used to sense a change in output voltage and control the bias on transistor A4Q1. The output of the voltage regulator is stable to within 1 percent.

(3) STANDBY BATTERY SUPPLY. - When primary power is applied to the unit, voltage from the secondary of stepdown transformer A5T1 is rectified by diode A5CR2 and applied to relay A5K1. Relay

A5K1 energizes and connects standby batteries A5TB1 and A5TB2, series-connected 12-volt batteries, to the 30-volt line through resistor A5R8, BATTERY circuit breaker A5CB3, and switch A5S1. During normal operation, the standby batteries are charged by the 30-volt line. When a power failure occurs, the voltage from relay rectifier A5CR2 is lost, but the relay remains energized by a voltage from the 30-volt line through zener diode A5CR1. The standby batteries supply power to the unit through diode A5CR4 until the battery voltage drops to approximately 18 volts. Zener diode A5CR1 stops conducting at 18 volts and disconnects the batteries from the circuit. When fully charged, the standby batteries will supply power to the frequency standard for at least 2 hours. Provisions are made for connecting an external battery through diode A5CR3. Diode A5CR3 allows current to be supplied to the units from an external battery, but prevents the external battery from being charged by the 30-volt rectifier circuit.

b. TEST DATA.

(1) REFERENCE ILLUSTRATIONS.

(a) Servicing block diagram, figure 4-1.

(b) Schematic diagram, figure 5-16.

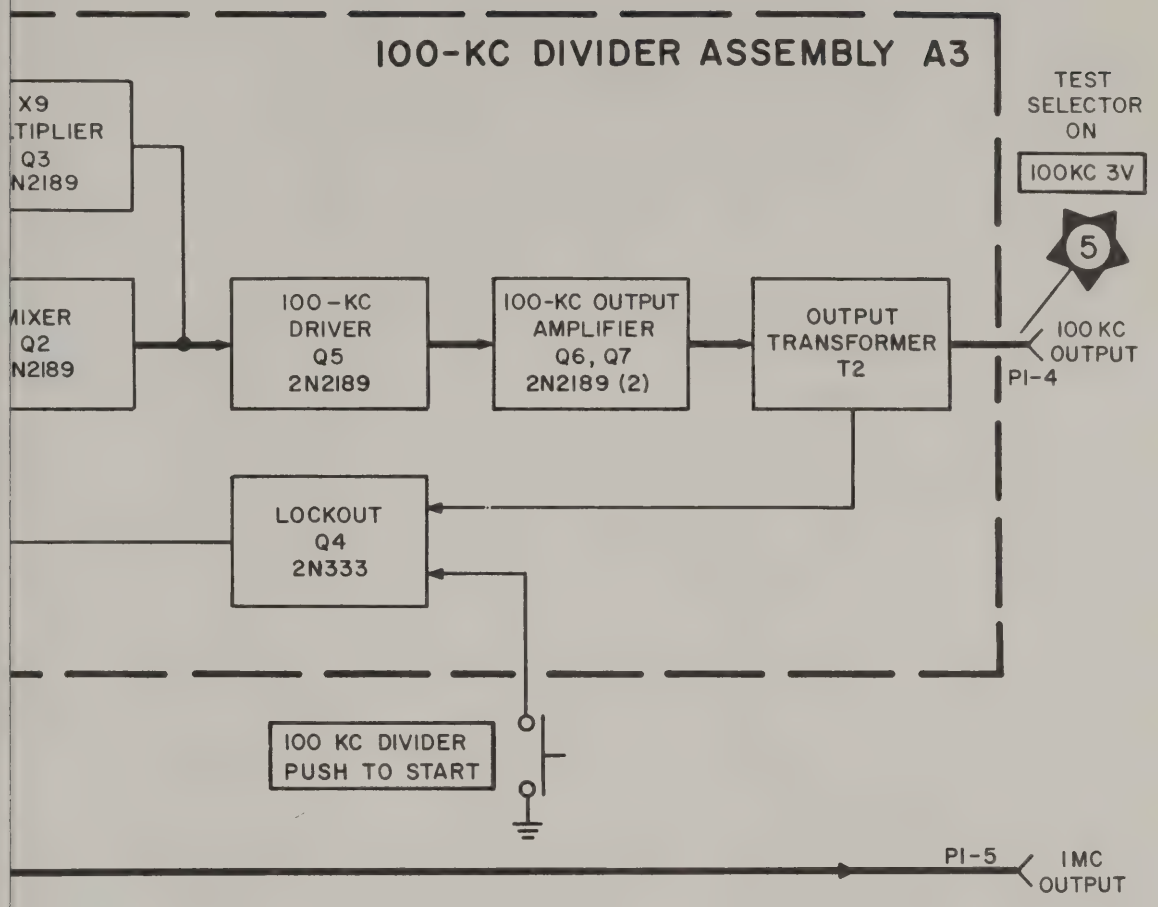
(c) Parts location illustrations, figures 5-1 through 5-4 and figure 5-15.

(2) CRITICAL ADJUSTMENTS. - Refer to the battery charging voltage adjustment procedure described in paragraph 5-2a.

(3) TEST INDICATIONS. - Use the front panel METER FULL SCALE test selector to check the power supply circuits.

(a) Set test selector to BAT 30V position. The meter should indicate approximately full scale when 115-volt ac primary power is supplied. If the frequency standard is operating on internal or external batteries, the meter should indicate 18.0 to 27.3 volts dc.

(b) Set test selector to REG 30V position. The meter should indicate 15 volts dc.



NOTES:

1. HEAVY LINES INDICATE MAIN SIGNAL PATHS.
2. LIGHT LINES INDICATE AUXILIARY OR SECONDARY SIGNAL PATHS.
3. ▭ INDICATES EQUIPMENT OPERATION AND ADJUSTMENT MARKINGS.

Figure 4-1. Frequency Standard O-1107/SRC-16, Servicing Block Diagram

A5K1 energizes and connects standby batteries A5TB1 and A5TB2, series-connected 12-volt batteries, to the 30-volt line through resistor A5R8, BATTERY circuit breaker A5CB3, and switch A5S1. During normal operation, the standby batteries are charged by the 30-volt line. When a power failure occurs, the voltage from relay rectifier A5CR2 is lost, but the relay remains energized by a voltage from the 30-volt line through zener diode A5CR1. The standby batteries supply power to the unit through diode A5CR4 until the battery voltage drops to approximately 18 volts. Zener diode A5CR1 stops conducting at 18 volts and disconnects the batteries from the circuit. When fully charged, the standby batteries will supply power to the frequency standard for at least 2 hours. Provisions are made for connecting an external battery through diode A5CR3. Diode A5CR3 allows current to be supplied to the units from an external battery, but prevents the external battery from being charged by the 30-volt rectifier circuit.

b. TEST DATA.

(1) REFERENCE ILLUSTRATIONS.

(a) Servicing block diagram, figure 4-1.

(b) Schematic diagram, figure 5-16.

(c) Parts location illustrations, figures 5-1 through 5-4 and figure 5-15.

(2) CRITICAL ADJUSTMENTS. - Refer to the battery charging voltage adjustment procedure described in paragraph 5-2a.

(3) TEST INDICATIONS. - Use the front panel METER FULL SCALE test selector to check the power supply circuits.

(a) Set test selector to BAT 30V position. The meter should indicate approximately full scale when 115-volt ac primary power is supplied. If the frequency standard is operating on internal or external batteries, the meter should indicate 18.0 to 27.2 volts dc.

(b) Set test selector to REG 30V position. The meter should indicate 15 volts dc.

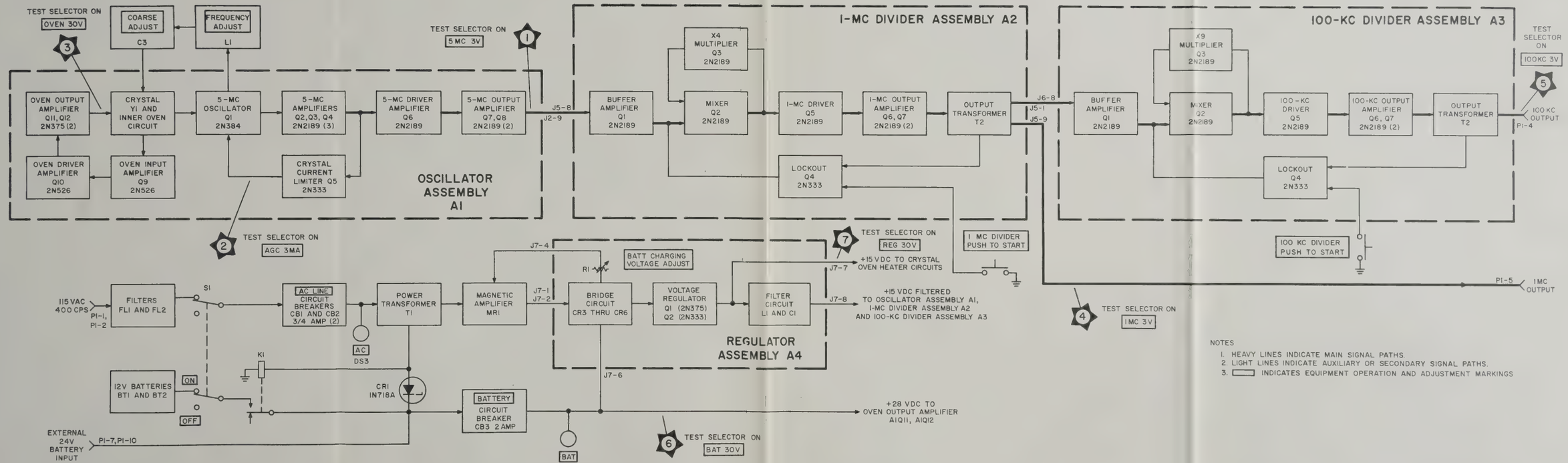


Figure 4-1. Frequency Standard O-1107/SRC-16, Servicing Block Diagram

SECTION 5

MAINTENANCE

5-1. PREVENTIVE MAINTENANCE.

Refer to the Maintenance Standards book for Radio Set AN/SRC-23(V), NavShips 0967-163-9070, for frequency standard preventive maintenance schedules and procedures.

5-2. ADJUSTMENT PROCEDURES.

a. BATTERY CHARGING VOLTAGE ADJUSTMENT.

(1) TEST EQUIPMENT REQUIRED.

(a) Multimeter CAOI-410C.

(2) PROCEDURE.

(a) Remove top dust cover from frequency standard.

(b) Connect vtvm to BATTERY circuit breaker CB3. Set vtvm to 30-volt dc scale.

(c) Loosen locknut on shaft of BATT CHARGING VOLTAGE ADJUST potentiometer A4R1 (figure 5-2). Set BATT CHARGING VOLTAGE ADJUST to obtain 30-volt dc indication on multimeter.

(d) Tighten locknut.

b. COARSE FREQUENCY ADJUSTMENT AND CRYSTAL AGING CALIBRATION.

(1) TEST EQUIPMENT AND SPECIAL TOOLS.

(a) Signal comparator unit 3A1.

(b) 100-kc primary frequency standard.

(c) Coarse frequency adjustment tool H2.

Note

Any one of the frequency standard units provided as part of the AN/SRC-23(V) may be used as the primary frequency standard if it is known to be accurate.

(2) TEST SETUP.

(a) For maintenance, pull the frequency standard out and remove the top dust cover.

(b) Remove the coarse frequency adjustment tool H2 from the electrical equipment chassis. Refer to figure 5-2.

(c) Remove the cover from the coarse frequency adjustment access hole on the front panel.

(d) Connect the primary 100-kc frequency standard to the signal comparator EXTERNAL STANDARD INPUT jack. Set signal comparator FREQUENCY STANDARD COMPARISON SWITCH NO. 2 to EXT STD.

Note

If one of the AN/SRC-23(V) frequency standards is used as the primary frequency standard, set the FREQUENCY STANDARD COMPARISON SWITCH NO. 2 to the appropriate position to select the primary frequency standard.

(e) Select the frequency standard which is to be adjusted by positioning signal comparator FREQUENCY STANDARD COMPARISON SWITCH NO. 1 to the appropriate position.

(3) PROCEDURE.

(a) Raise the frequency standard frequency adjustment cover plate, and loosen the lock on the adjustment wheel.

(b) Set the FREQUENCY ADJUST PARTS IN 10^{10} to 400. Tighten the lock.

Note

If the crystal is aging negative (decreasing frequency with time), set FREQUENCY ADJUST-PARTS IN 10^{10} to 100.

(c) Insert coarse frequency adjustment tool H2 into access hole (figure 3-1), and turn until the signal comparator indicates zero frequency difference. Refer to signal comparator operating procedures described in chapter A, section 2. Replace access hole cover.

(d) Allow frequency standard to operate for 24 hours. Then repeat step (c) above.

(e) Allow frequency standard to operate for 60 days. Each week during this period, adjust FREQUENCY ADJUST PART IN 10^{10} for zero frequency difference as indicated by the signal comparator. Record the setting of the FREQUENCY ADJUST PARTS IN 10^{10} each time it is adjusted. On the basis of this information, a crystal aging rate can be determined which will allow periodic adjustment of the output frequency and thereby ensure long-term accuracy. The frequency standard can be considered a primary frequency standard only after 60 days of operation and after the crystal aging rate has been determined.

5-3. REPAIR.

a. REMOVAL OF FREQUENCY STANDARD FROM CABINET. - The frequency standard is removed from the cabinet by loosening wingnuts on two outside collet fasteners, turning wingnut on center extractor screw counterclockwise to loosen, and pulling unit out of cabinet. The power automatically

switches to battery operation. Installation is the reverse of removal.

Loosen the top cover of the frequency standard by disengaging the two finger-actuated buckles at the top front of the unit and slipping the cover off the two dowel pins located at the top rear. The bottom cover of the unit can be removed by loosening 16 quarter-turn fasteners which secure the cover to the unit.

b. REMOVAL OF MODULES AND ASSEMBLIES. - Assemblies may be removed by loosening the Phillips-head mounting screws. To remove modules and assemblies, perform the following steps:

(1) Remove dust covers from assemblies A2 and A3 by removing 2 screws on top of assembly and 2 on each side.

(2) Remove dust cover from assembly A4 by removing 6 screws from right side and 2 screws from left side.

(3) Remove dust cover from assembly A1 by removing 12 screws on top and 9 on each side. Remove 2 recessed screws at each end of baseplate bottom to remove dust cover end plates.

c. BATTERY REPLACEMENT. - Perform the following steps to replace batteries BT1 and BT2 (figure 5-4):

(1) Remove six screws holding battery compartment cover on rear of unit. Remove bottom dust cover.

(2) Unsolder one end of the wire connecting the two batteries. This wire connects the positive (red) end of one battery to the negative (white) end of the other battery.

(3) Slide both batteries to the rear of the unit cabinet as far as the wires will allow. Unsolder the wire connected to the negative (white) end of the front of the battery pair.

(4) Unsolder the wire connected to the positive (red) end of the battery pair. Remove both batteries from the frequency standard.

(5) Discard damaged battery, and obtain replacement battery. Do not replace battery pair at this time.

(6) Connect a 25-ohm, 10-watt resistor across one battery, and record its voltage under load. Remove the resistor.

(7) Connect the 25-ohm, 10-watt resistor across the other battery, and record its voltage under load. Remove the resistor.

(8) Connect the 25-ohm, 10-watt resistor to the battery that reads the highest voltage under load, and allow it to remain in place until the voltage under load is equal to that of the other (lowest voltage) battery.

(9) When both batteries read the same voltage under load, replace them by performing steps (1) through (4) in reverse order.

d. DISASSEMBLY OF OSCILLATOR ASSEMBLY A1. - Refer to figures 5-5 and 5-6.

(1) REMOVAL OF OVEN AMPLIFIER BOARD A1TB3. - To remove oven amplifier board A1TB3, remove four screws from front of terminal board. Removal of this board permits access to terminals of transformers A1T3, A1T4, and A1T5.

(2) REMOVAL OF OVEN OUTPUT AMPLIFIER BOARD. - To remove the oven amplifier board, remove two recessed screws from bottom of subassembly baseplate and two screws from left side of shield bracket between A1TB1 and oven output amplifier board. Removal of this board provides access to transistors A1Q11 and A1Q12 and resistor A1R36.

(3) REMOVAL OF 5-MC AMPLIFIER BOARD A1TB2 AND 5-MC DRIVER AND OUTPUT AMPLIFIER BOARD A1TB1. - To remove 5-mc amplifier board A1TB2 and 5-mc driver and output amplifier board A1TB1, remove two recessed screws from bottom of subassembly baseplate, and remove the two boards as a unit. To remove individual boards, remove screws securing each board to shield plate.

(4) REMOVAL OF 5-MC CRYSTAL OSCILLATOR OVENS. - Perform the following steps to remove the 5-mc crystal oscillator ovens:

(a) Remove outer half of outer oven insulation block by carefully prying upward from baseplate with fingers. Outer oven A1HR2 will be exposed.

(b) Remove four fillister-head screws mounted in a ring around the outer oven at adjustment end. (Adjustment end is the end toward front of frequency standard.)

(c) Remove one screw securing plug A1P5 to oven connector end. (Connector end is opposite adjustment end.) Remove connector.

(d) Remove one screw securing plate beneath plug A1P5. Remove plate. (Threading a long 2-56 screw into a tapped hole in the plate will simplify its removal.)

(e) Carefully separate inner oven A1HR1 from outer oven A1HR2 by pulling them apart. Guide connector A1P5 through hole in connector end of outer oven.

(f) To gain access to both sides of oscillator terminal boards, remove four screws in corners of terminal board.

(g) If maintenance must be performed on the windings of inner oven A1HR1, remove the surrounding insulation by cutting the lacing ties at each end of oven, and peel back insulation. Do not remove this insulation unless absolutely necessary.

(h) To gain access to crystal A1Y1 and its associated reactive components, remove the inner oven. Remove one screw from connector end of inner oven A1HR1. Remove four screws mounted in a ring around adjustment end of inner oven A1HR1, and slowly slide inner oven off crystal assembly.

CAUTION

When performing maintenance on the crystal or the reactive components in the inner oven, be careful not to damage the sealed crystal by heat from a soldering iron. When soldering leads near the crystal, grip the crystal leads with long-nosed pliers to absorb heat that would otherwise be transmitted to the crystal.

(5) REASSEMBLY OF 5-MC CRYSTAL OSCILLATOR OVENS. - When reassembling the crystal oscillator ovens, coat the crystal and reactive components mounting board with a heat conducting grease, such as Dow-Corning silicone grease type DC-4. Perform steps (e) through (h) in paragraph 5-3d(4) in reverse order. Coat the outer surface of the inner oven insulation with a thin film of heat conducting grease before proceeding with reassembly. Perform steps (a) through (d) in paragraph 5-3d(4) in reverse order.

e. PRINTED CIRCUIT BOARD REPAIR. - Parts mounted on the printed circuit boards are bonded to the boards to protect them from damage caused by humidity and moisture. This bonding (postcoating) also serves to protect the parts against excessive vibration in service. If the repair process requires that a part be removed from the board and replaced with another part, the following procedure should be followed. The bonding agent to be used in recoating the boards is a postcoating material, Dennis 1169 (FSN 5970-738-5960). This material, consists of two parts, Dennis 1169A and Dennis 1169B, which must be mixed.

(1) Inspect the board for evidence of burns, scorches, heat damage, corroded metal parts or terminals, or delamination of the base laminate. If any of these defects are evident, replace the entire board rather than attempting repair. If the board appears repairable, proceed to step 2.

(2) Remove the designated part from the printed board by destroying the protective postcoating with a hot soldering iron; then unsolder the part, and lift it off the board with a pair of long-nosed pliers.

CAUTION

Do not use soldering irons rated above 100 watts on boards bearing transistors, Cerafil capacitors, or other heat sensitive components. Exercise care when removing components from printed circuit boards so that the circuitry is not damaged.

(3) If necessary, remove the excess solder from the joint with a soldering iron.

(4) Insert the new wire or component lead in the correct tubelet, and clinch the wire over the tubelet.

(5) Apply solder to the joint using any rosin flux core solder conforming to QQ-S-571 type AR or 63/37 (tin-lead) solid wire solder and rosin flux. Do not use a solder that has a core of hydrazine, acid, or other unapproved flux. Do not keep the iron on the joint longer than necessary to complete the solder flow throughout the joint.

(6) Inspect the solder joint to be sure the solder completely covers metal surfaces, component leads, tubelets, eyelets, or terminals which have been soldered and that there is a smooth continuous fillet of solder between tubelet flares and the circuitry. Also, note that there are no cold or fractured solder joints or nonadherence of solder to metal and no excess solder globules, peaks, strings, or bridges of solder between adjacent parts or circuits.

(7) Clean the joint to remove the flux, using a medium-bristled brush and a small amount of organic solvent, such as trichloroethylene, toluol, or proprietary solvents (such as Freon TMC). Remove as much of the melted plastic and flux from the soldered area as possible. Remove excess solvent and dissolved flux with absorbent material.

Note

Use solvent sparingly, since the postcoating also will be dissolved. Apply a small amount to the area of the solder joint.

(8) Mix together one part of Dennis 1169A liquid with one part Dennis 1169B liquid in a stainless steel, wax-free paper or polyethylene container, and stir with a stainless steel spatula or equivalent. Mix thoroughly.

(9) Apply the Dennis 1169 mixture to the newly soldered joint (or joints), covering all areas where the original coating was damaged and any new components which were added. Use a soft-bristled brush to apply the Dennis 1169.

(10) Allow the newly coated boards to dry to a tack-free condition (approximately 2 hours) before reassembling the module. The final cure will take approximately 7 days at room temperature or 1 hour at +60°C (+140°F). However, the equipment may be operated during the curing period.

f. PARTS LOCATION ILLUSTRATIONS. - Refer to figures 5-1 through 5-15 for parts locations.

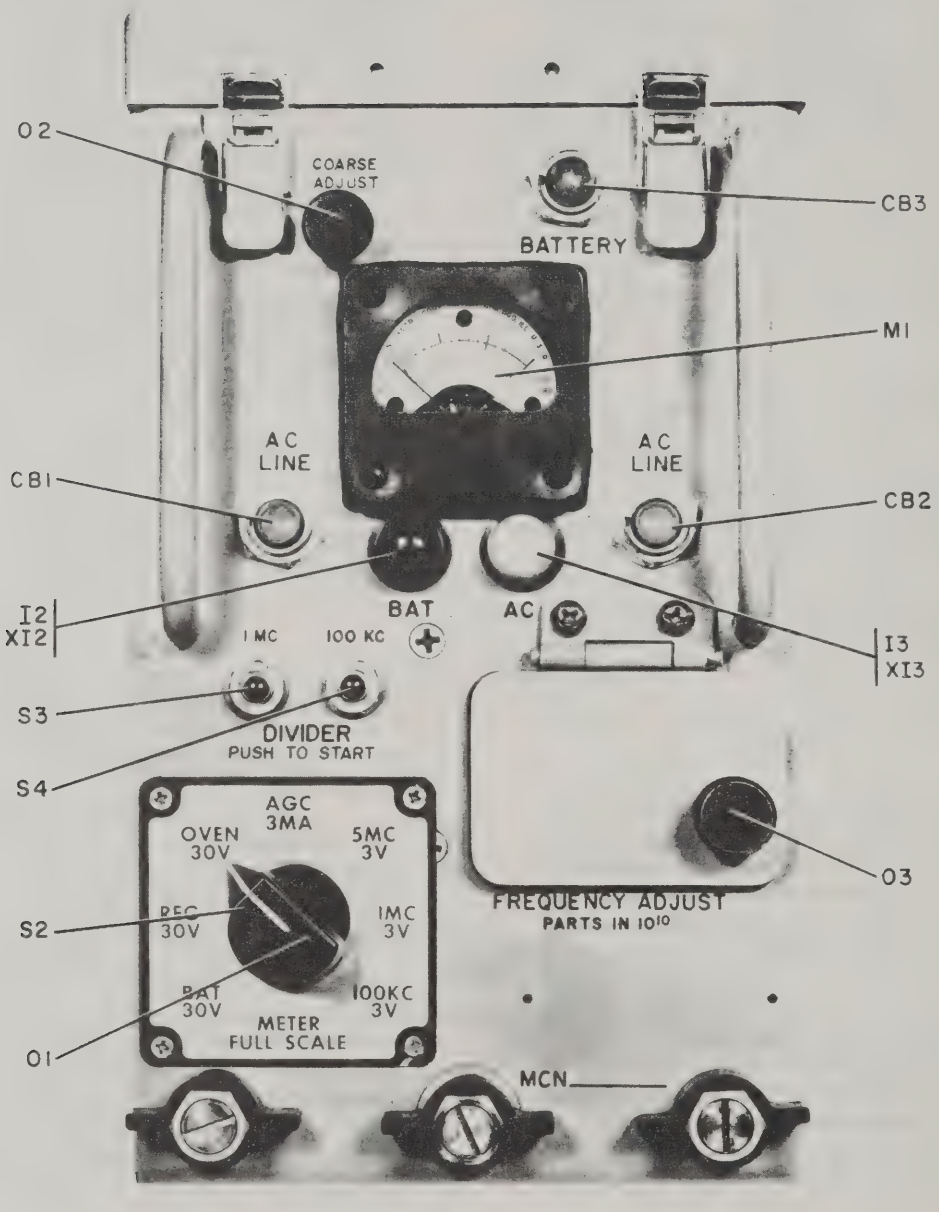


Figure 5-1. Front Panel, Parts Location

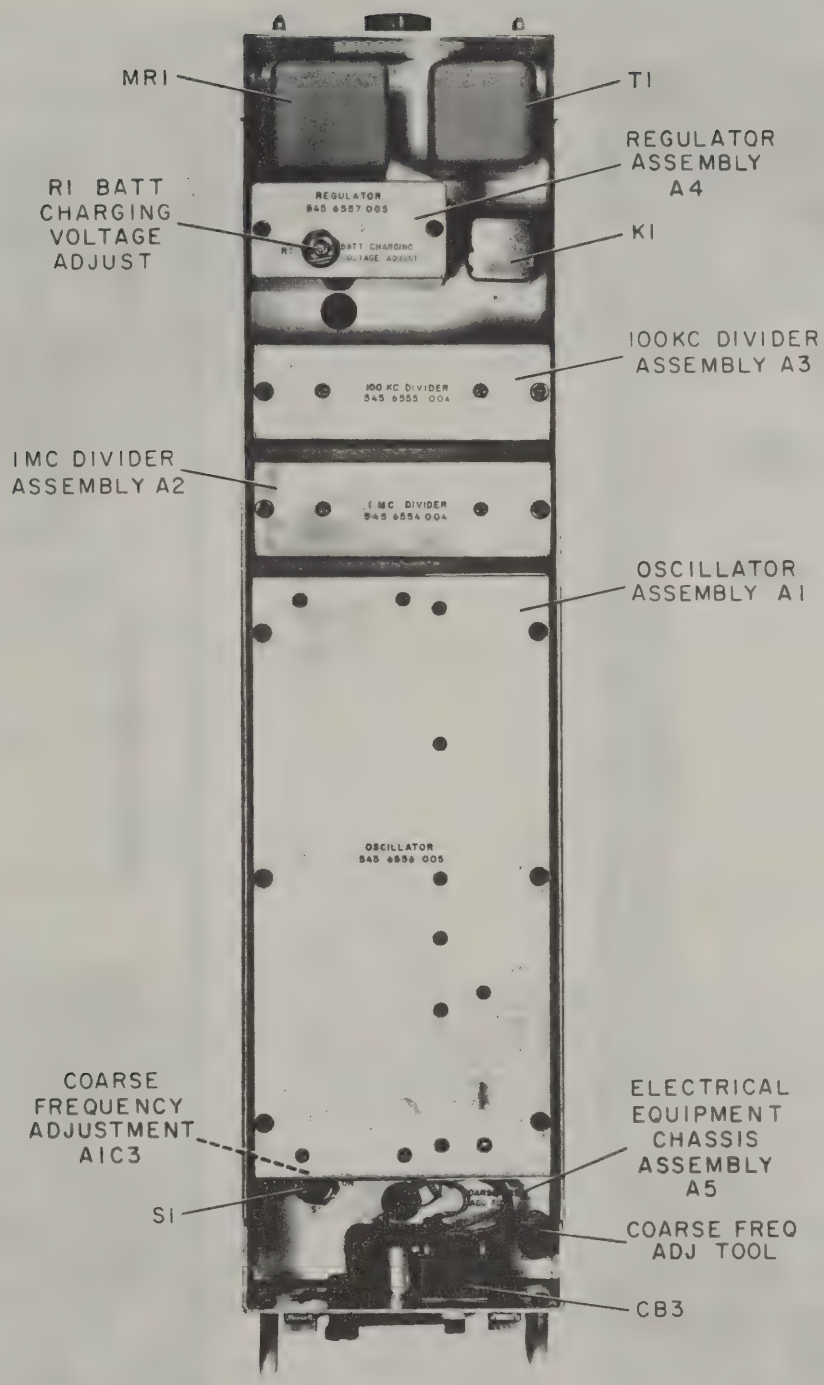


Figure 5-2. Top View, Cover Removed, Parts Location

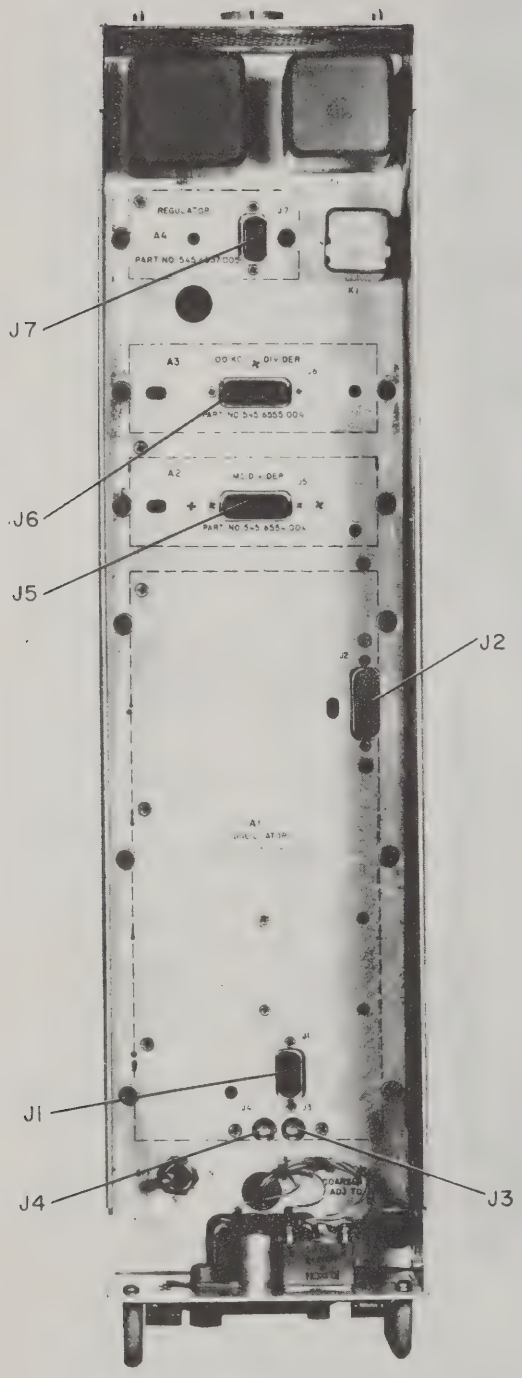


Figure 5-3. Top View, Assemblies Removed, Parts Location

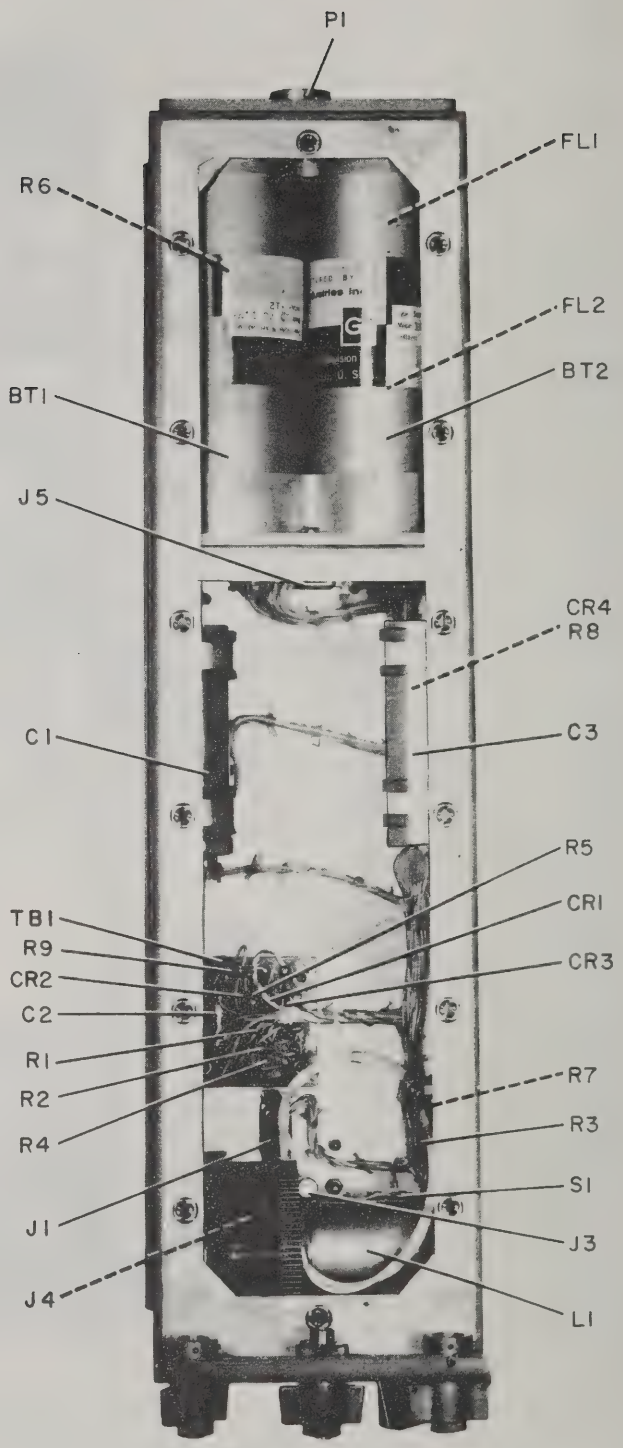


Figure 5-4. Bottom View, Parts Location

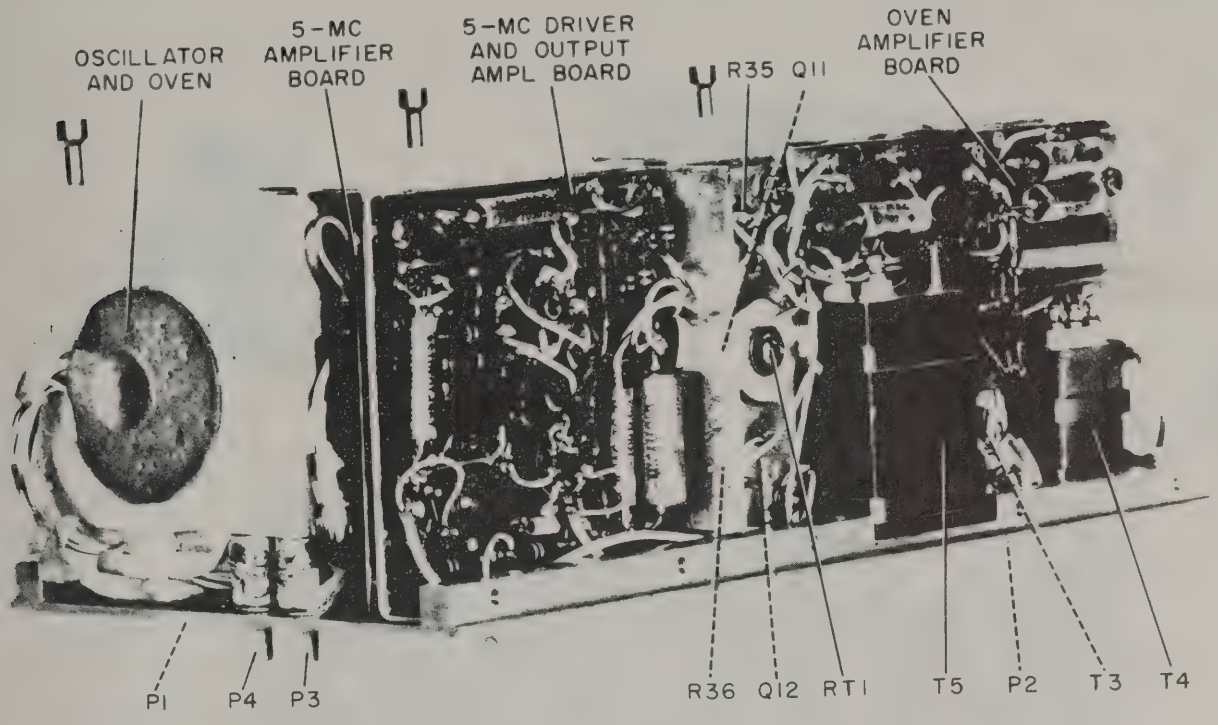


Figure 5-5. Oscillator Assembly A1, Parts Location

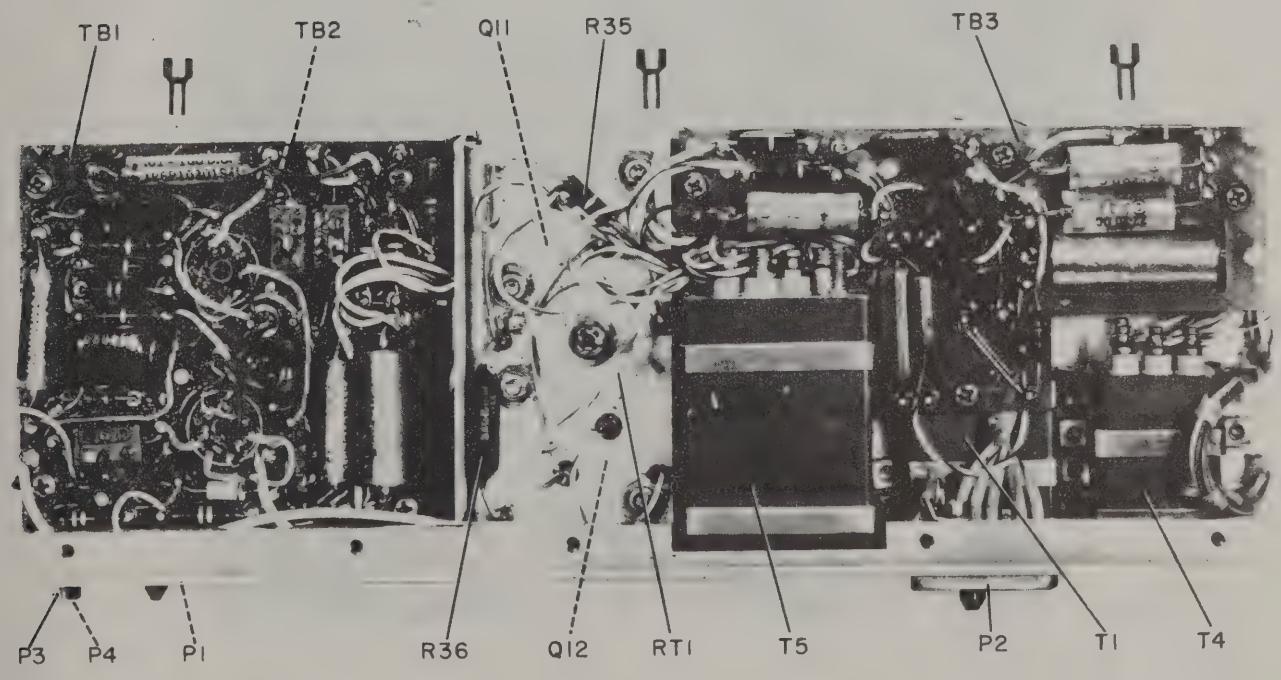


Figure 5-6. Oscillator Assembly A1, Parts Location

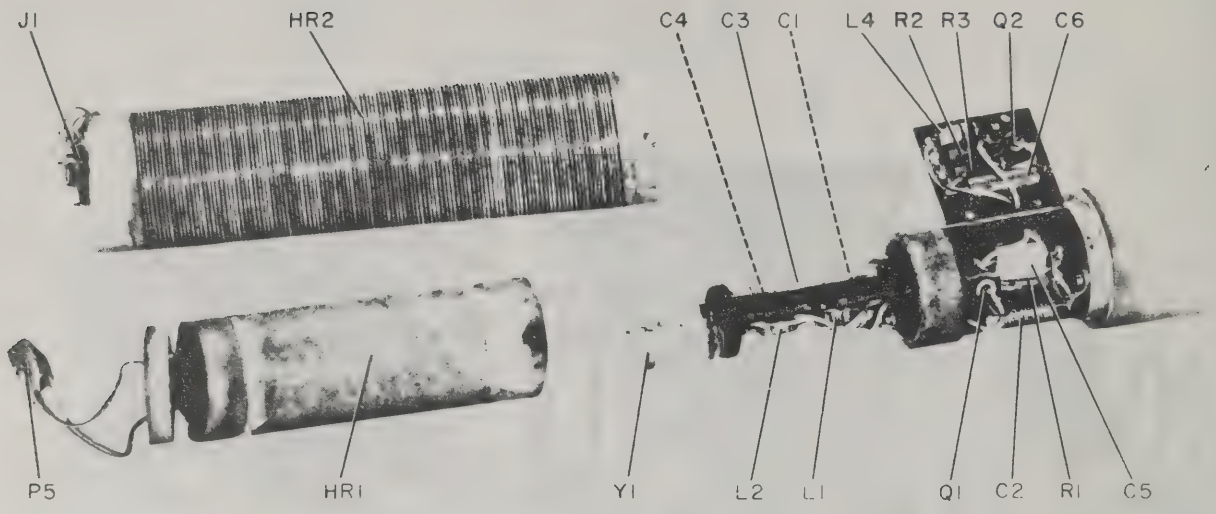


Figure 5-7. Oscillator Assembly A1, Oscillator and Inner Oven, Parts Location

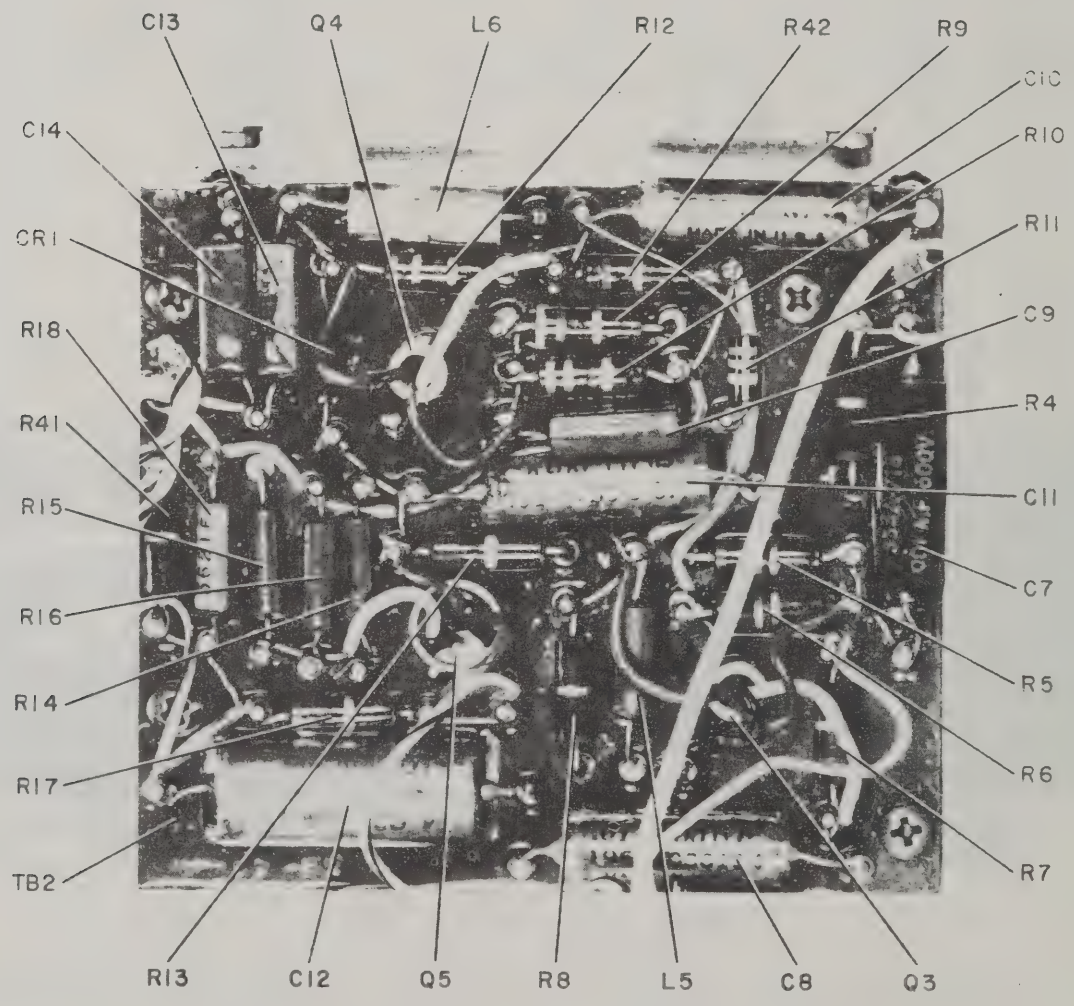


Figure 5-8. Oscillator Assembly A1, Amplifier Board A1TB2, Parts Location

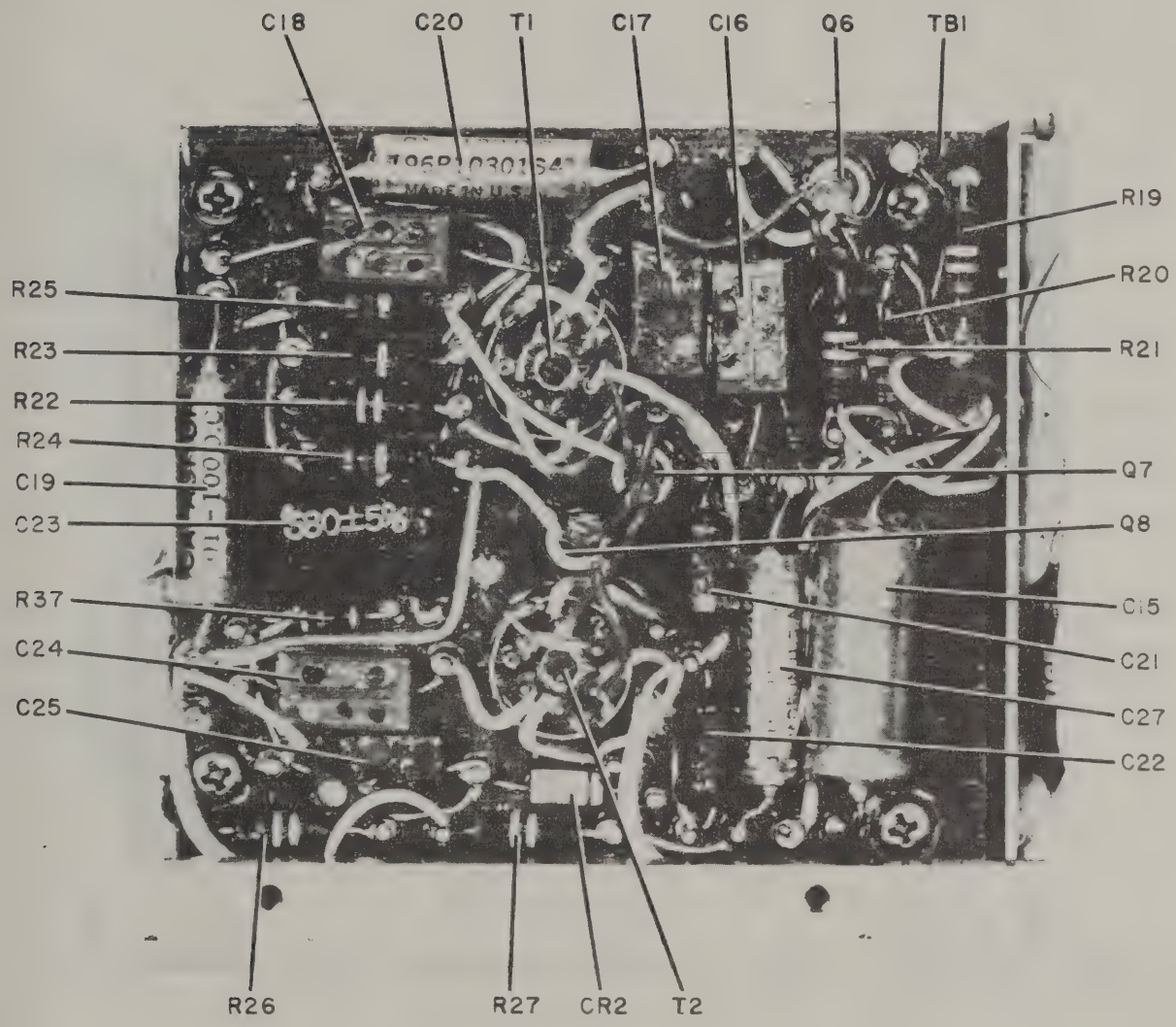


Figure 5-9. Oscillator Assembly A1, Output Board A1TB1, Parts Location

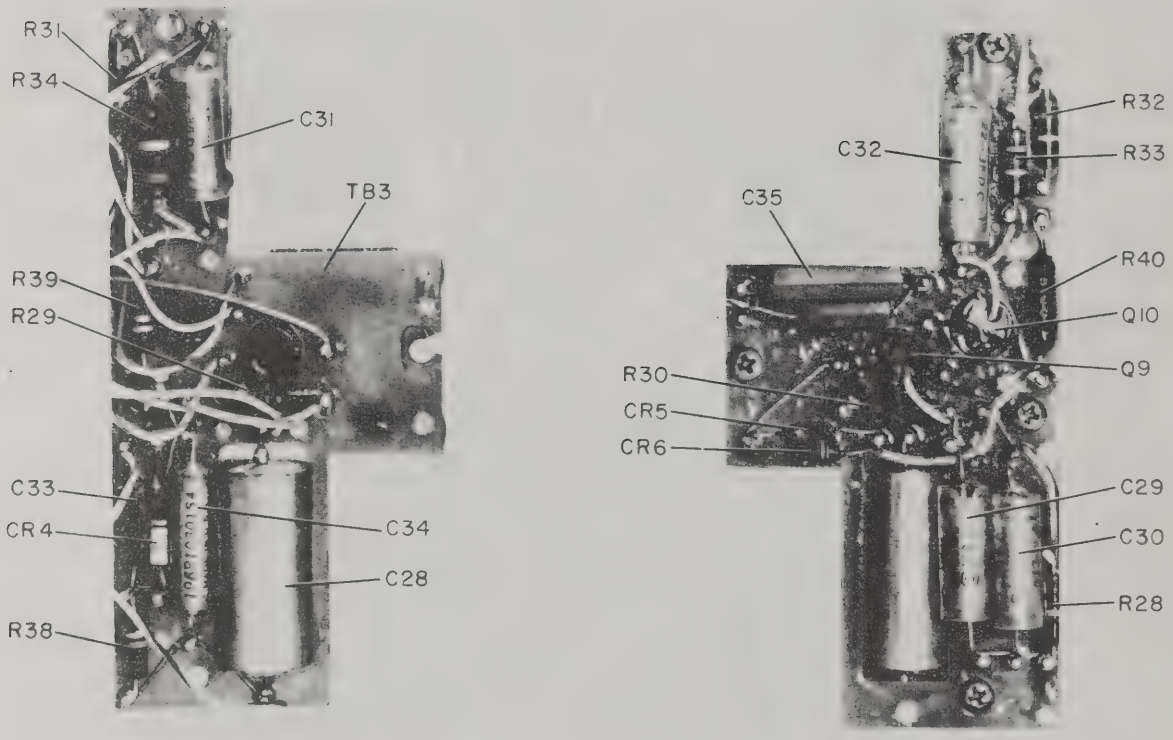


Figure 5-10. Oscillator Assembly A1, Crystal Oven Control Board A1TB3, Parts Location

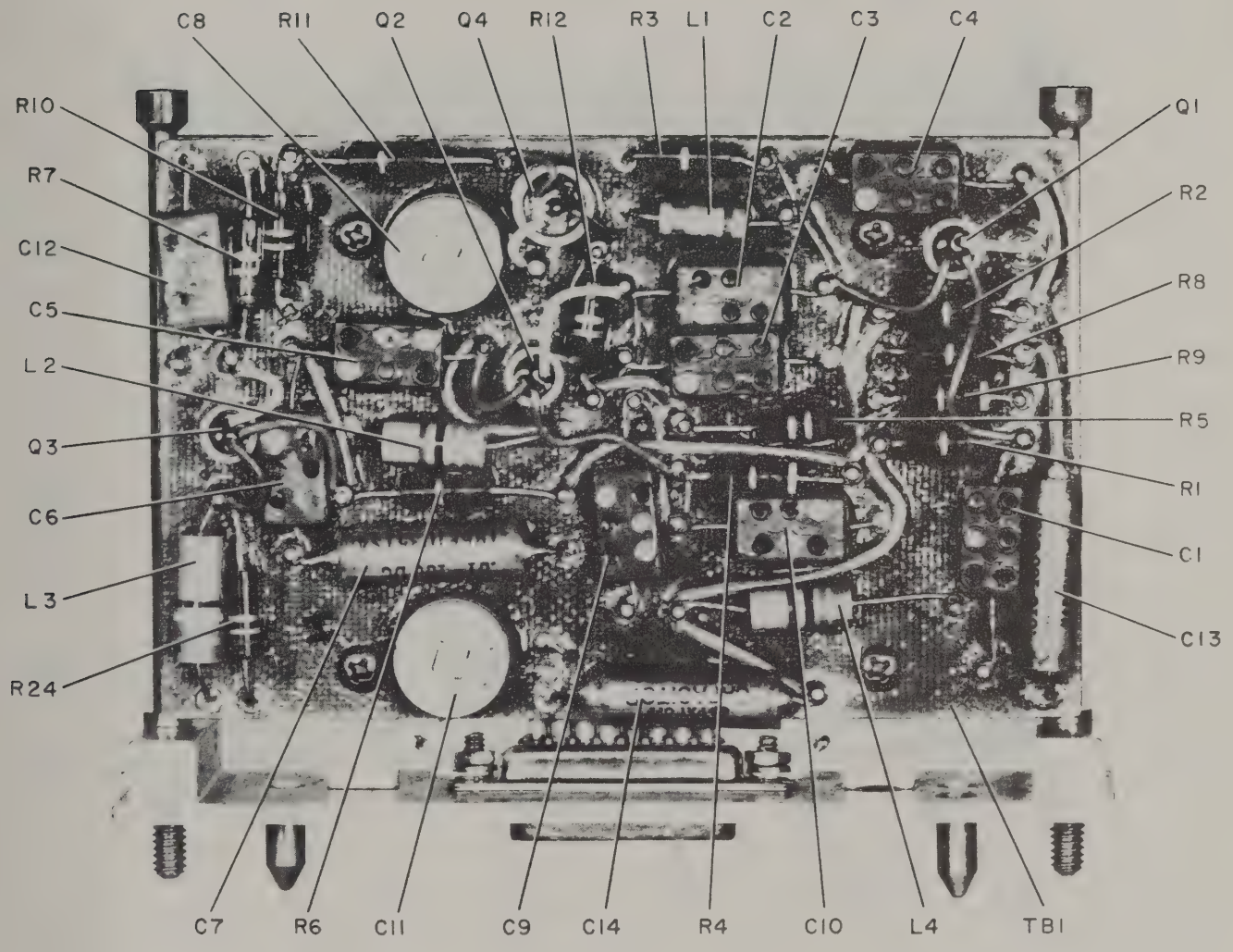


Figure 5-11. 1-Mc Divider Assembly A2, Divider Board A2TB1, Parts Location

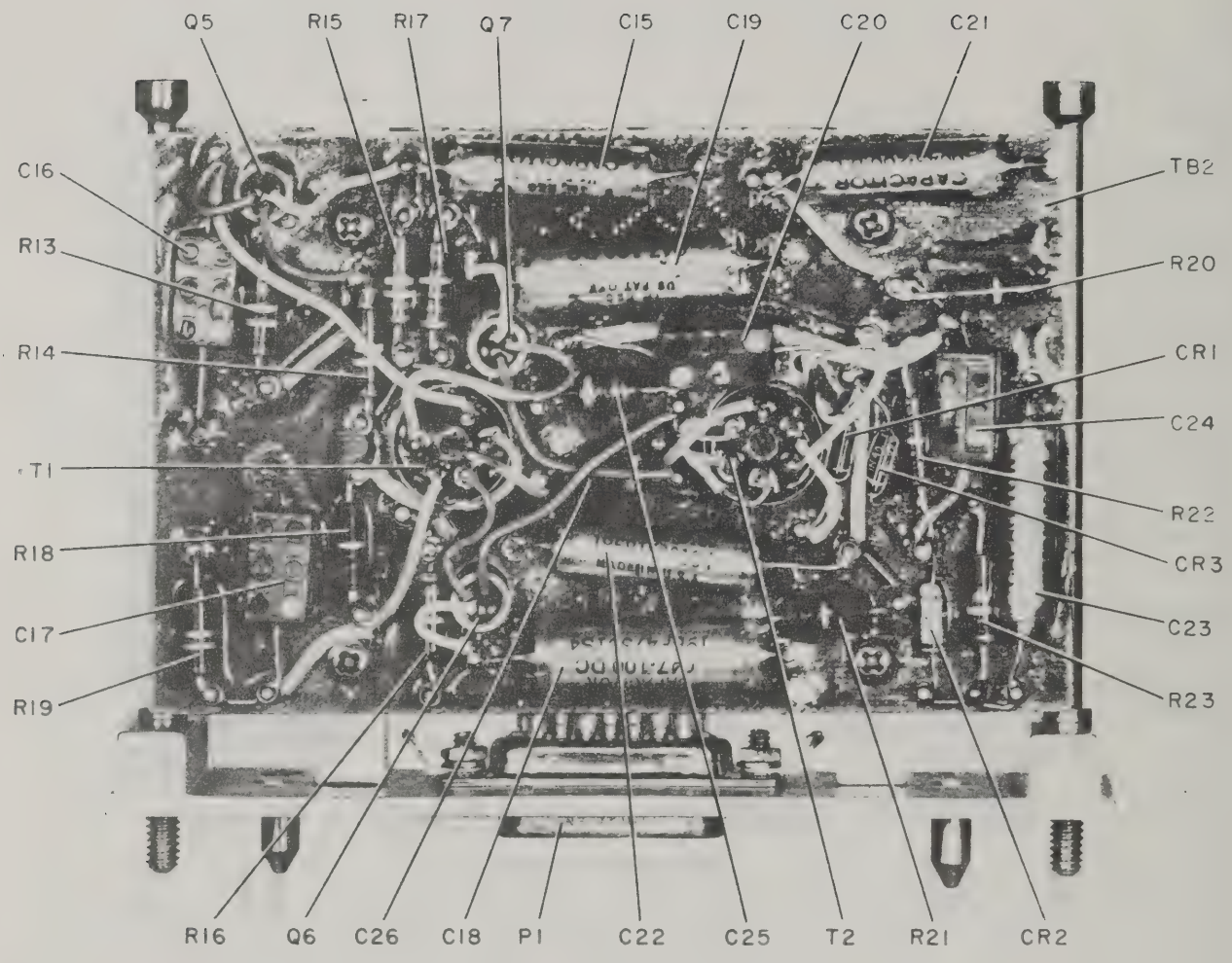


Figure 5-12. 1-Mc Divider Assembly A2, Amplifier Board A2TB2, Parts Location

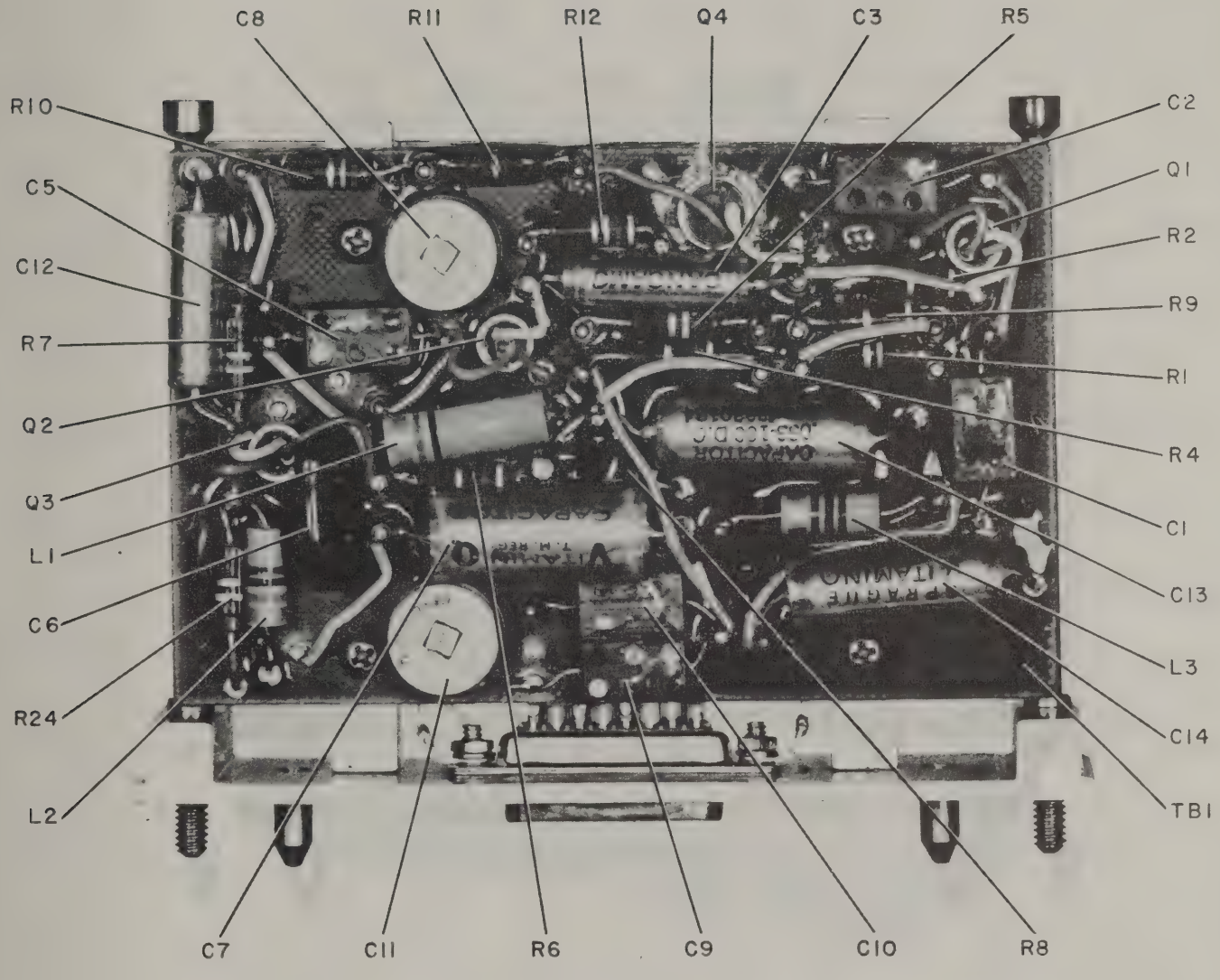


Figure 5-13. 100-Kc Divider Assembly A3, Divider Board A3TB1, Parts Location

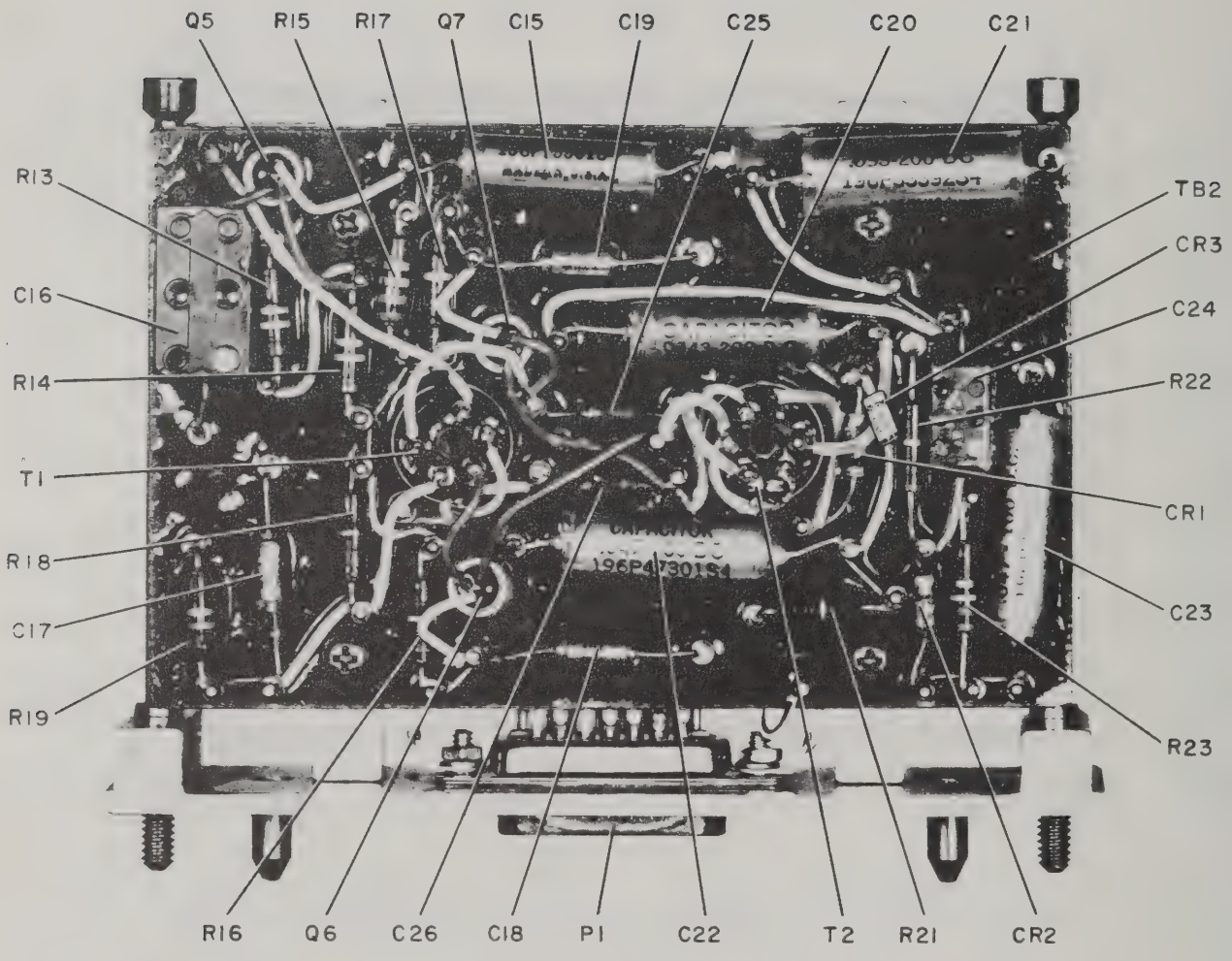


Figure 5-14. 100-Kc Divider Assembly A3, Amplifier Board A3TB2, Parts Location

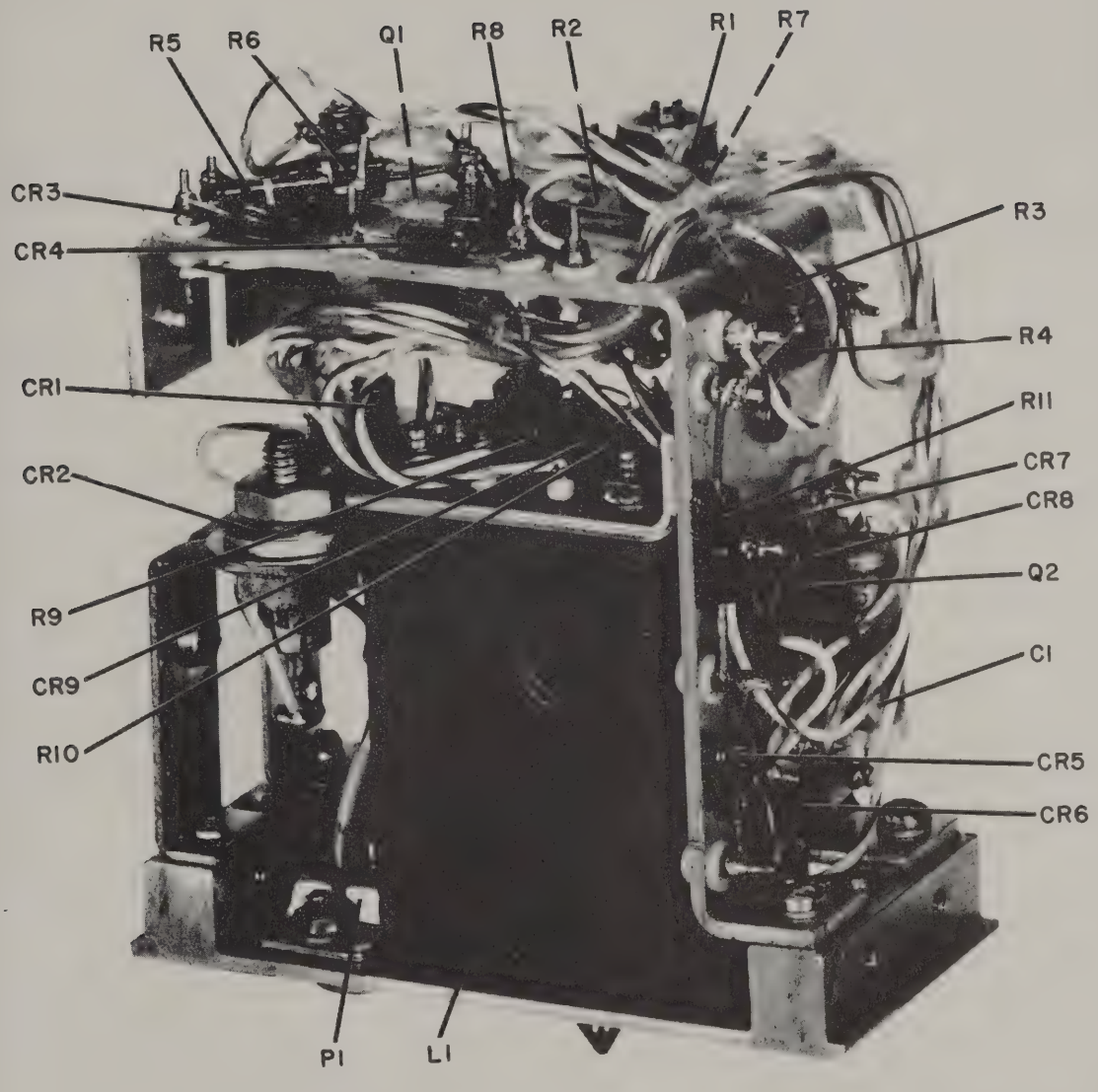
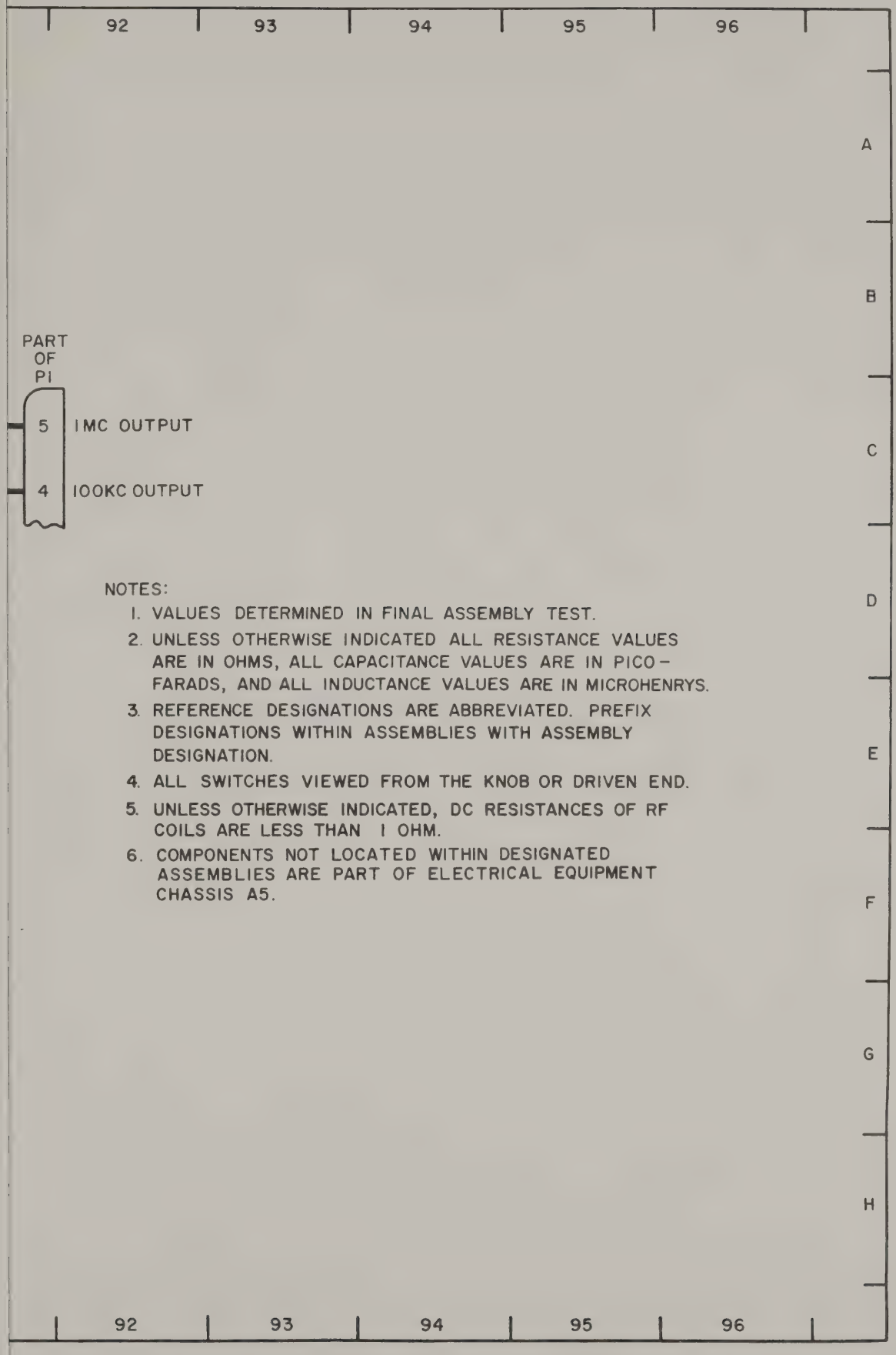
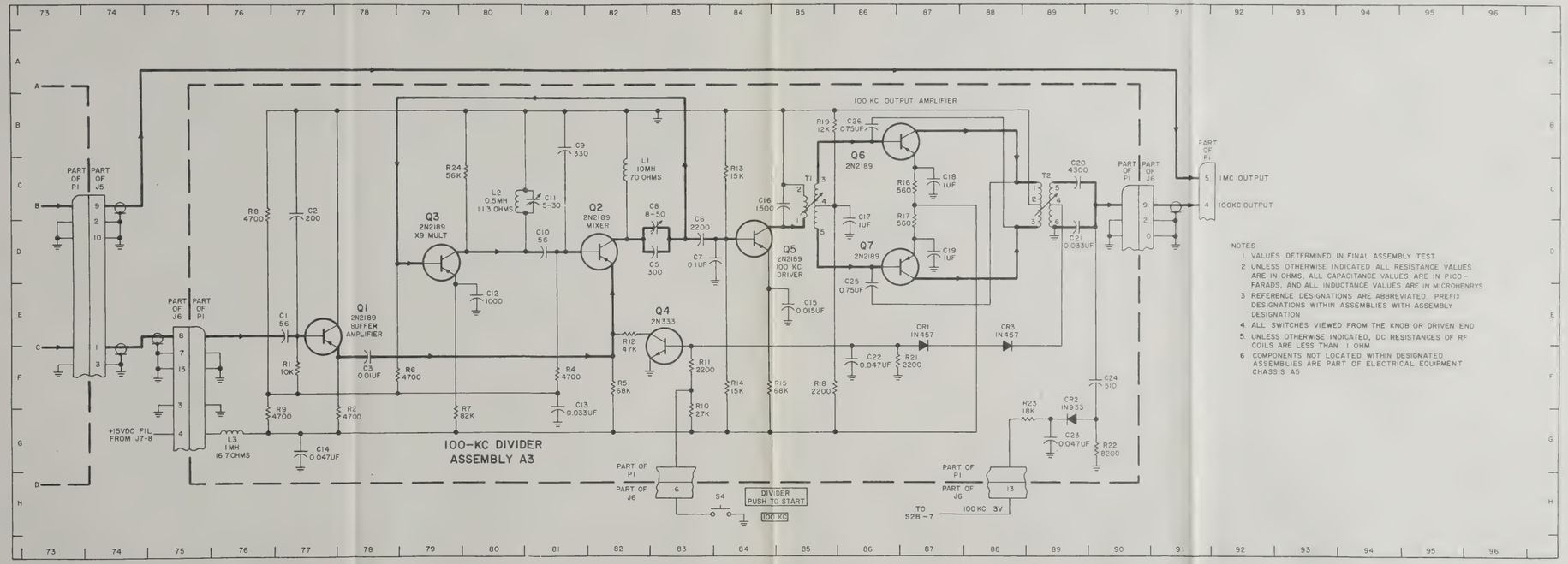


Figure 5-15. Regulator Assembly A4, Parts Location



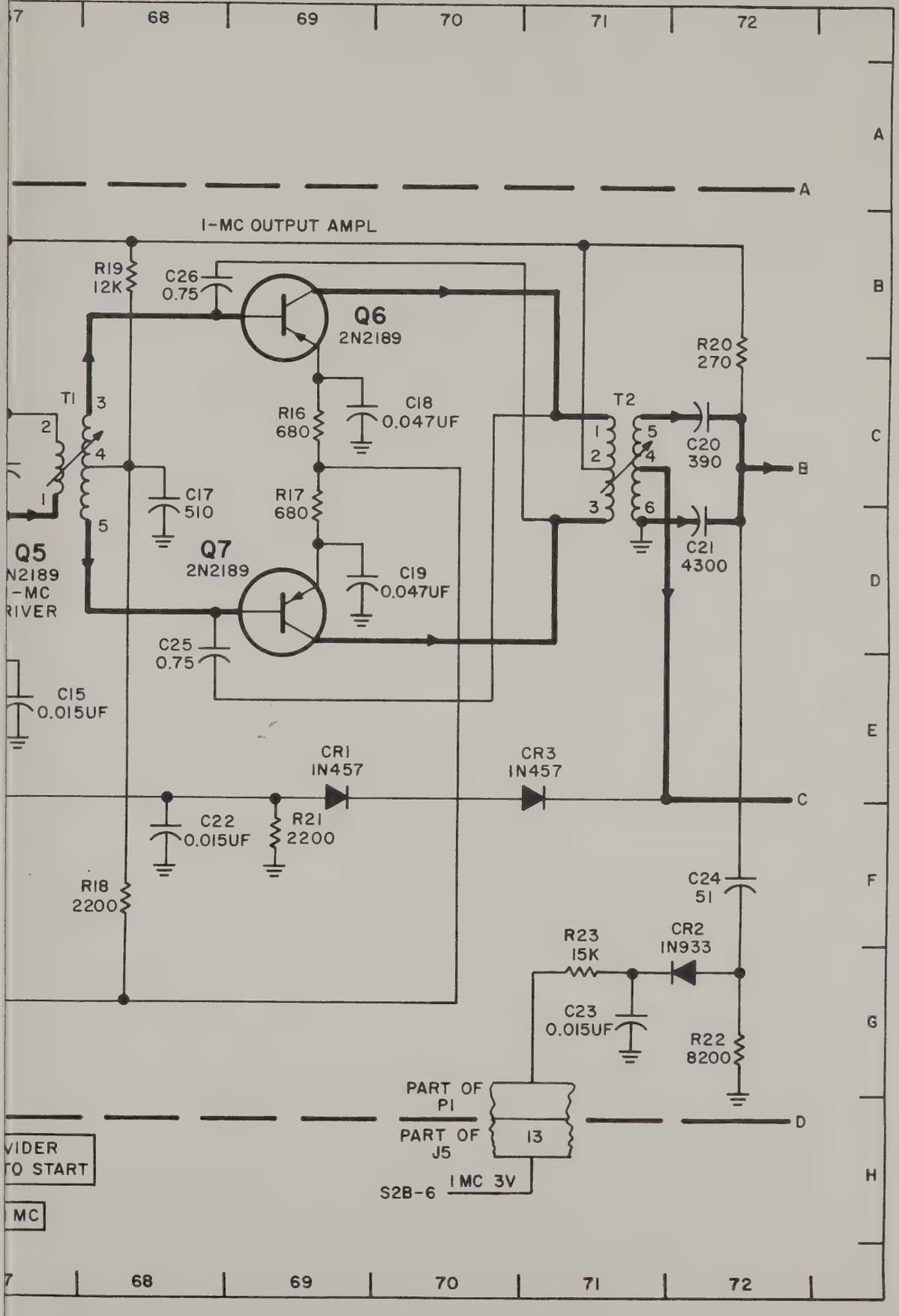
ure 5-16. Frequency Standard O-1107/SRC-16, Schematic Diagram (Sheet 1 of 4)

REF DESIG	LOC	REF DESIG	LOC	REF DESIG	LOC	REF DESIG	LOC	REF DESIG	LOC	REF DESIG	LOC	REF DESIG	LOC
BT1	3C	R8	4C	A1HR2	35C	A1R20	48E	A2C18	69C	A3C11	81C	A3R4	81F
BT2	3D	S1	5B	A1J1	36C	A1R21	50E	A2C19	69D	A3C12	80E	A3R5	82F
C1	18B	S2A	22B	A1L1	37C	A1R22	51B	A2C20	72C	A3C13	81F	A3R6	79F
C2	6C	S2B	22F	A1L2	38D	A1R23	51E	A2C21	72D	A3C14	77G	A3R7	80G
C3	4C	S3	66H	A1L4	41C	A1R24	42D	A2C22	68F	A3C15	85E	A3R8	76C
CB1	5D	S4	84H	A1L5	44C	A1R25	52G	A2C23	71G	A3C16	84C	A3R9	77G
CB2	5F	T1	7D	A1L6	46C	A1R26	54G	A2C24	72F	A3C17	86C	A3R10	83F
CB3	8B	A1C1	38C	A1P1	42H,	A1R27	53G	A2C25	68D	A3C18	87C	A3R11	83F
CR1	6B	A1C2	39E		53H,	A1R28	33E	A2C26	68B	A3C19	87D	A3R12	82E
CR2	7C	A1C3	39C		47B	A1R29	33E	A2CR1	69E	A3C20	89C	A3R13	84C
CR3	4B	A1C4	38C	A1P2	31B,	A1R30	26F	A2CR2	72G	A3C21	89D	A3R14	84F
CR4	4B	A1C5	40E		26G,	A1R31	27C	A2CR3	71E	A3C22	86F	A3R15	84F
DS2	8B	A1C6	41E		56D	A1R32	27E	A2L1	60C	A3C23	89G	A3R16	87C
DS3	5E	A1C7	43D	A1P3	38A	A1R33	28E	A2L2	64C	A3C24	90F	A3R17	87C
FL1	3D	A1C8	44E	A1P4	40A	A1R34	29B	A2L3	62C	A3C25	86D	A3R18	85F
FL2	3F	A1C9	44D	A1P5	36C	A1R35	29D	A2L4	58G	A3C26	86B	A3R19	85B
J1	42H,	A1C10	46E	A1Q1	39D	A1R36	30C	A2P1	58E	A2R23	71G	A3R21	87F
	47A,	A1C11	47G	A1Q2	41D	A1R37	55G	A2Q1	60D	A2R24	62C	A3R22	90G
	52H	A1C12	40G	A1Q3	44D	A1R38	31G	A2Q2	64D	A2T1	67C	A3R23	89G
J2	25G,	A1C13	47D	A1Q4	45D	A1R39	29G	A2Q3	61D	A2T2	71C	A3R24	80C
	31A,	A1C14	47D	A1Q5	44G	A1R40	34E	A2Q4	65E	A3C1	77E	A3T1	85C
	56D	A1C15	53F	A1Q6	49D	A1R41	40G	A2Q5	67D	A3C2	77C	A3T2	89C
J3	38A	A1C16	50E	A1Q7	53C	A1R42	46E	A2Q6	69B	A3C3	78F	A4C1	17D
J4	40A	A1C17	50D	A1Q8	52E	A1RT1	29C	A2Q7	69D	A3C5	83D	A4CR1	10D
J5	57E,	A1C18	51D	A1Q9	26E	A1T1	51C	A2R1	59F	A3C6	83D	A4CR2	10G
	65H,	A1C19	53D	A1Q10	28D	A1T2	54C	A2R2	60G	A3C7	83D	A4CR3	12D
	70H,	A1C20	53C	A1Q11	31C	A1T3	27D	A2R3	60C	A3C8	83C	A4CR4	13D
	74C	A1C21	51E	A1Q12	31D	A1T4	28C	A2R4	63F	A3C9	81B	A4CR5	11F
J6	75E,	A1C22	51B	A1R1	40C	A1T5	32C	A2R5	64F	A3CR1	87E	A4CR6	12F
	82H,	A1C23	55G	A1R2	40E	A1Y1	38D	A2R6	61F	A3CR2	89G	A4CR7	17F
	87H,	A1C24	55D	A1R3	41F	A2C1	59E	A2R7	62G	A3CR3	88E	A4CR8	17G
	90C	A1C25	55G	A1R4	42C	A2C2	61E	A2R8	59C	A3L1	82C	A4CR9	16D
J7	9C,	A1C27	53G	A1R5	43C	A2C3	62E	A2R9	59G	A3L2	80C	A4L1	17C
	10C	A1C29	26D	A1R6	43E	A2C4	60F	A2R10	66G	A3L3	76G	A4P1	10C
K1	6C	A1C29	27F	A1R7	44E	A2C5	65D	A2R11	66F	A3P1	76E,	A4Q1	15C
L1	39A	A1C30	34E	A1R8	44C	A2C6	66C	A2R12	65E		82G,	A4Q2	14E
M1	22D	A1C31	27E	A1R9	45C	A2C7	66D	A2R13	66C		88G,	A4R1	13E
MR1	8C	A1C32	25E	A1R10	45E	A2C8	65C	A2R14	66F		90C	A4R2	13F
P1	3A,	A1C33	31G	A1R11	46F	A2C9	63D	A2R15	67F	A3Q1	78E	A4R3	11D
	91B	A1C34	30G	A1R12	47F	A2C10	63D	A2R16	69C	A3Q2	82C	A4R4	11E
R1	23D	A1C35	32D	A1R13	45G	A2C11	63C	A2R17	69C	A3Q3	79D	A4R5	14D
R2	23E	A1CR1	47G	A1R14	45G	A2C12	62E	A2R18	68F	A3Q4	83E	A4R6	14D
R3	6F	A1CR2	54G	A1R15	46F	A2C13	62F	A2R19	68B	A3Q5	85D	A4R7	14E
R4	8C	A1CR4	30G	A1R16	45F	A2C14	59G	A2R20	72B	A3Q6	86B	A4R8	15E
R5	7C	A1CR5	33D	A1R17	43F	A2C15	67E	A2R21	69F	A3Q7	86D	A4R9	17E
R6	5C	A1CR6	34D	A1R18	42F	A2C16	67C	A2R22	72G	A3R1	77F	A4R10	16F
R7	6E	A1HR1	36C	A1R19	48C	A2C17	68C	A3C10	81D	A3R2	78G	A4R11	11F



NOTES
1. VALUES DETERMINED IN FINAL ASSEMBLY TEST
2. UNLESS OTHERWISE INDICATED, ALL RESISTANCE VALUES ARE IN OHMS, ALL CAPACITANCE VALUES ARE IN PICO-FARADS, AND ALL INDUCTANCE VALUES ARE IN MICROHENRYS
3. REFERENCE DESIGNATIONS ARE ABBREVIATED. PREFIX DESIGNATIONS WITHIN ASSEMBLIES WITH ASSEMBLY DESIGNATION
4. ALL SWITCHES VIEWED FROM THE KNOB OR DRIVEN END
5. UNLESS OTHERWISE INDICATED, DC RESISTANCES OF RF COILS ARE LESS THAN 1 OHM
6. COMPONENTS NOT LOCATED WITHIN DESIGNATED ASSEMBLIES ARE PART OF ELECTRICAL EQUIPMENT CHASSIS A5

Figure 5-16. Frequency Standard O-1107/SRC-16, Schematic Diagram (Sheet 1 of 4)



gure 5-16. Frequency Standard O-1107/SRC-16, Schematic Diagram (Sheet 2 of 4)

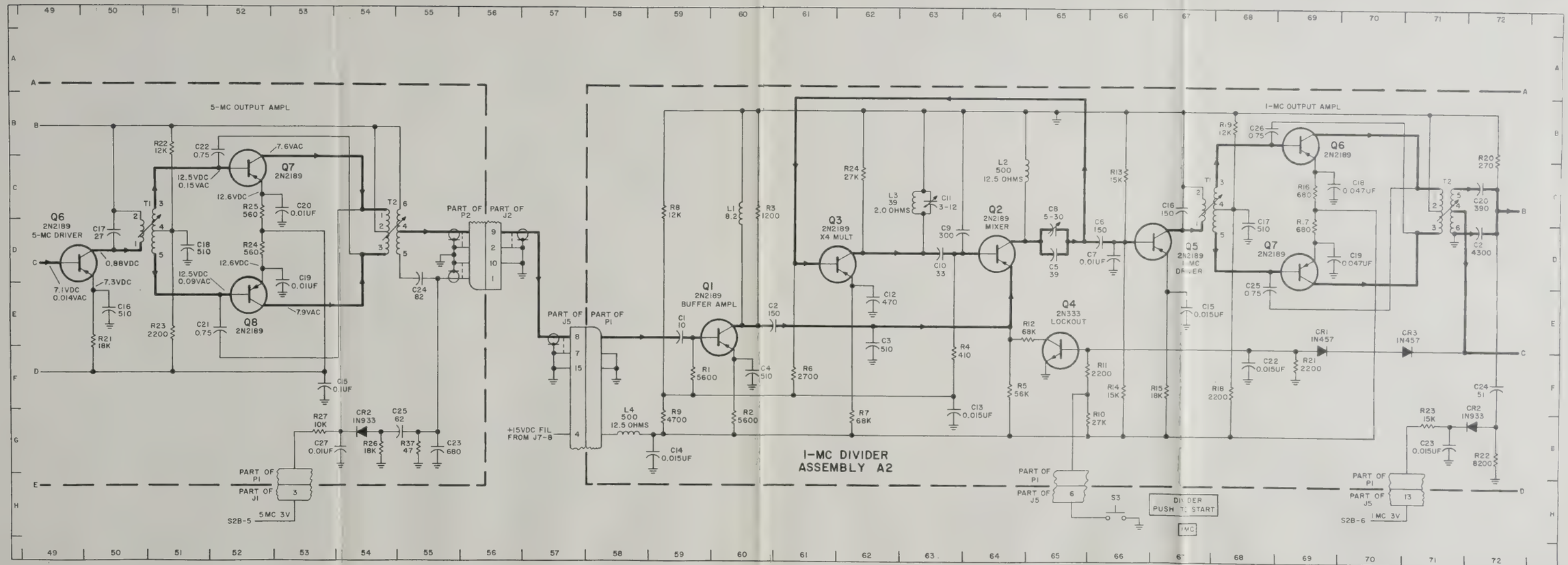
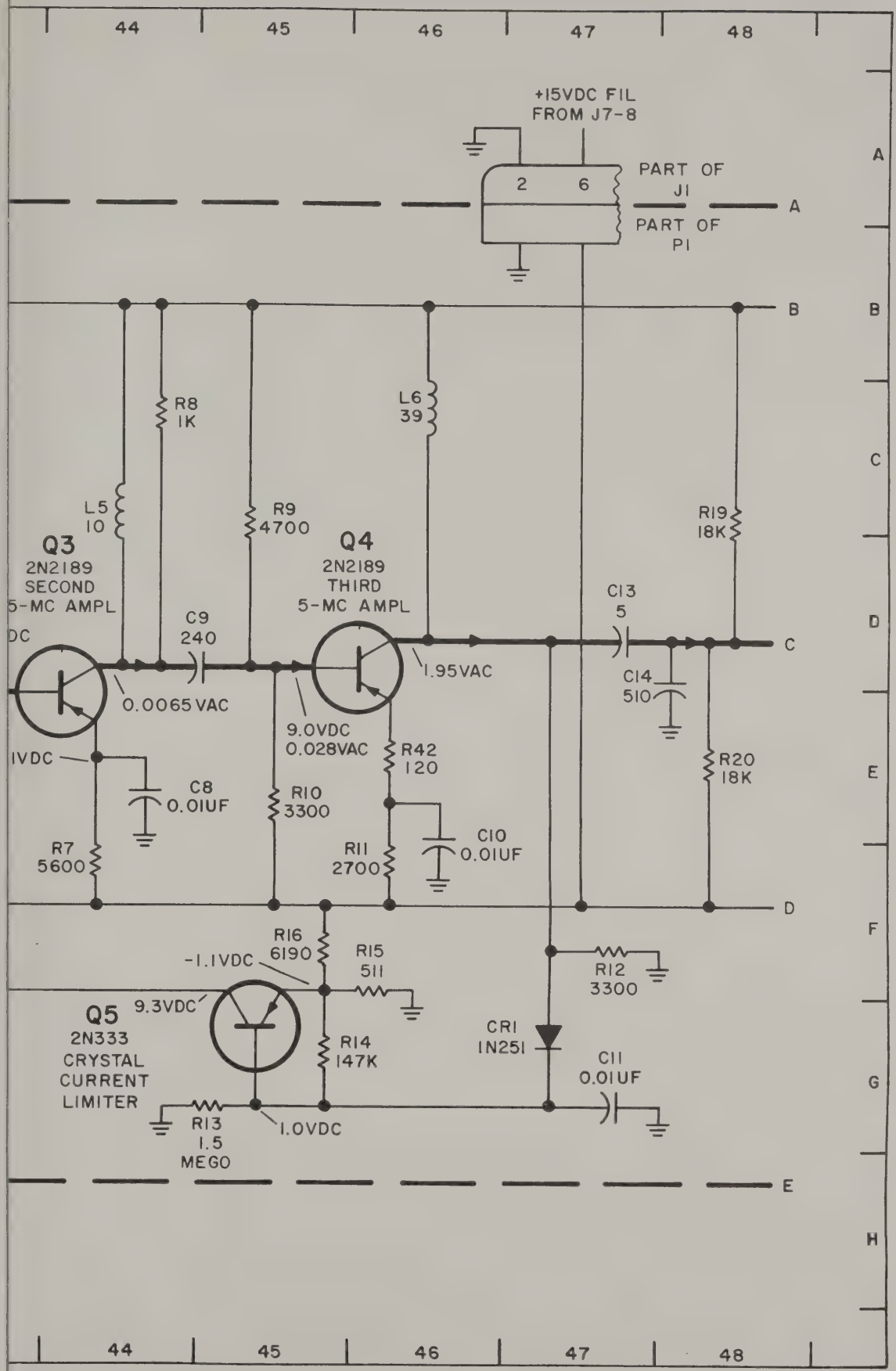


Figure 5-16. Frequency Standard O-1107/SRC-16, Schematic Diagram (Sheet 2 of 4)



5-16. Frequency Standard O-1107/SRC-16, Schematic Diagram (Sheet 3 of 4)

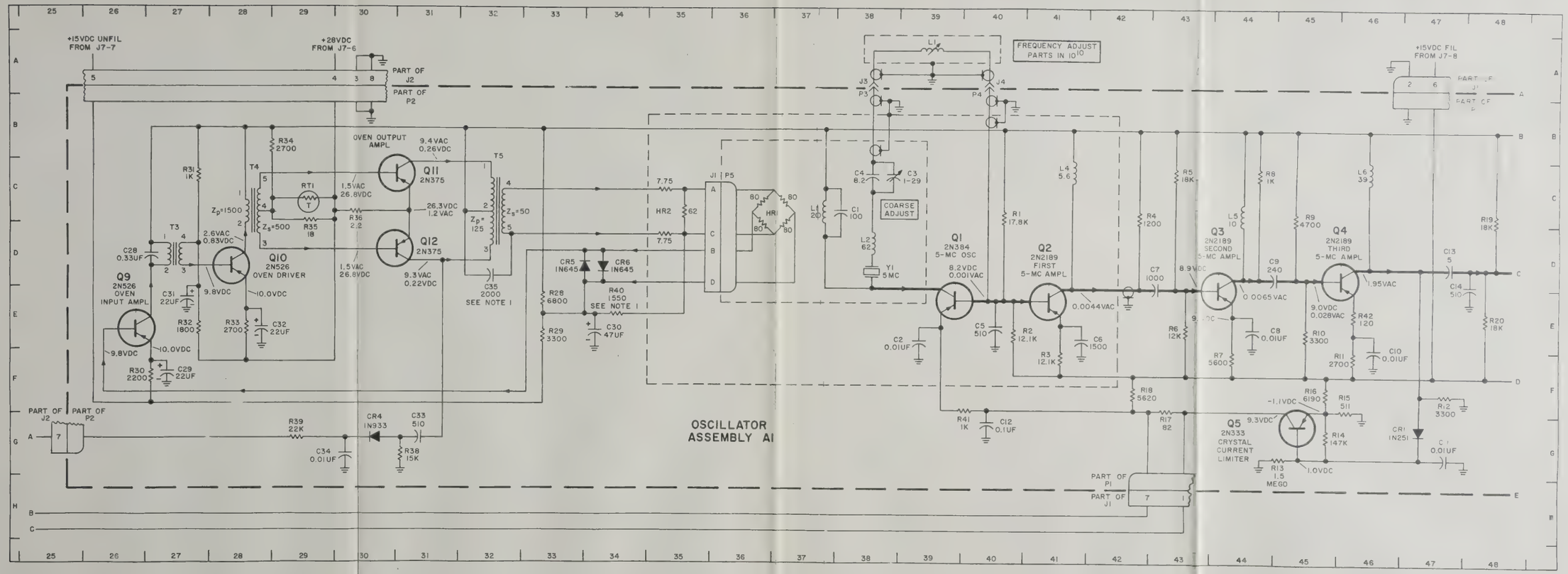
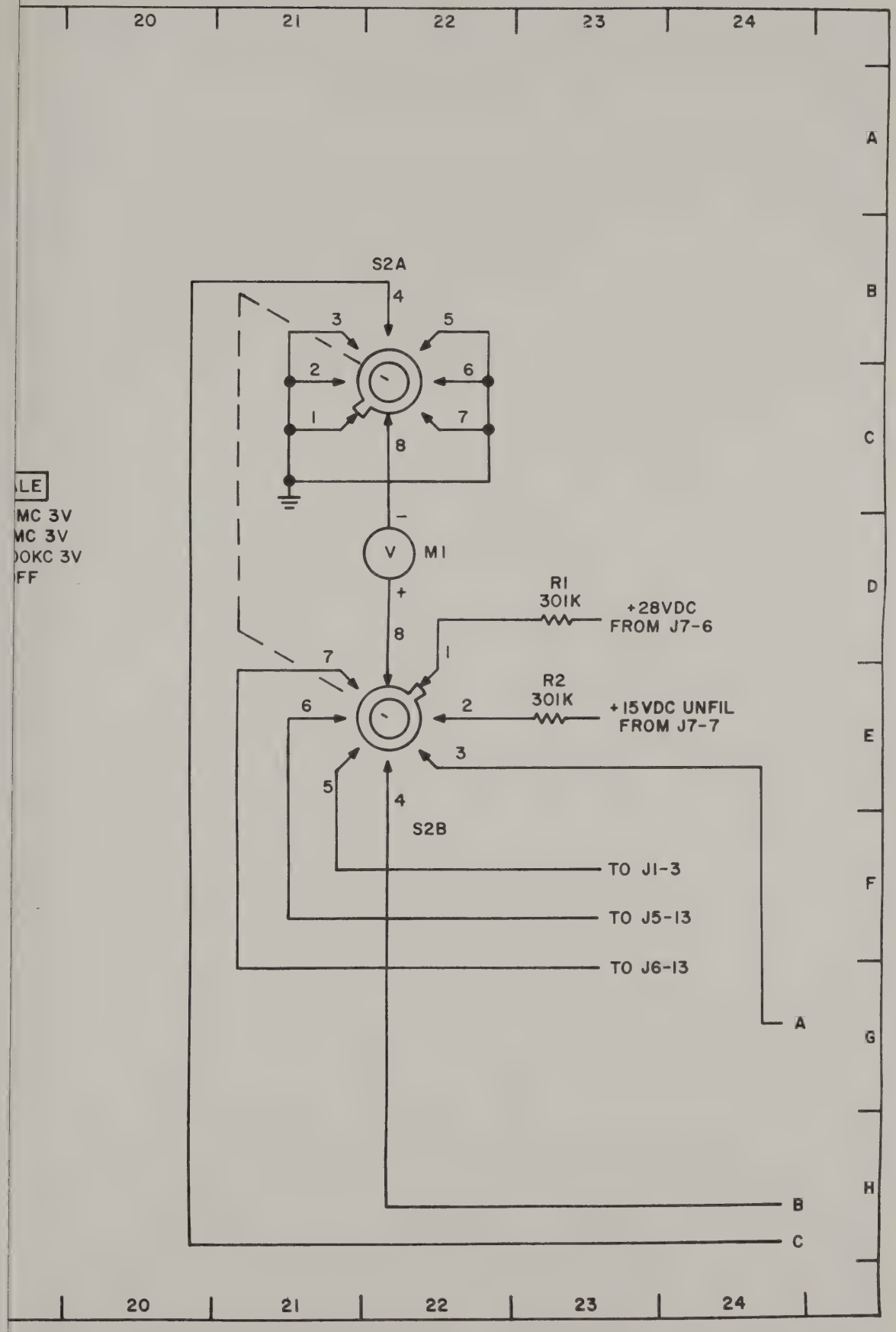


Figure 5-16. Frequency Standard O-1107/SRC-16, Schematic Diagram (Sheet 3 of 4)



ıre 5-16. Frequency Standard O-1107/SRC-16, Schematic Diagram (Sheet 4 of 4)

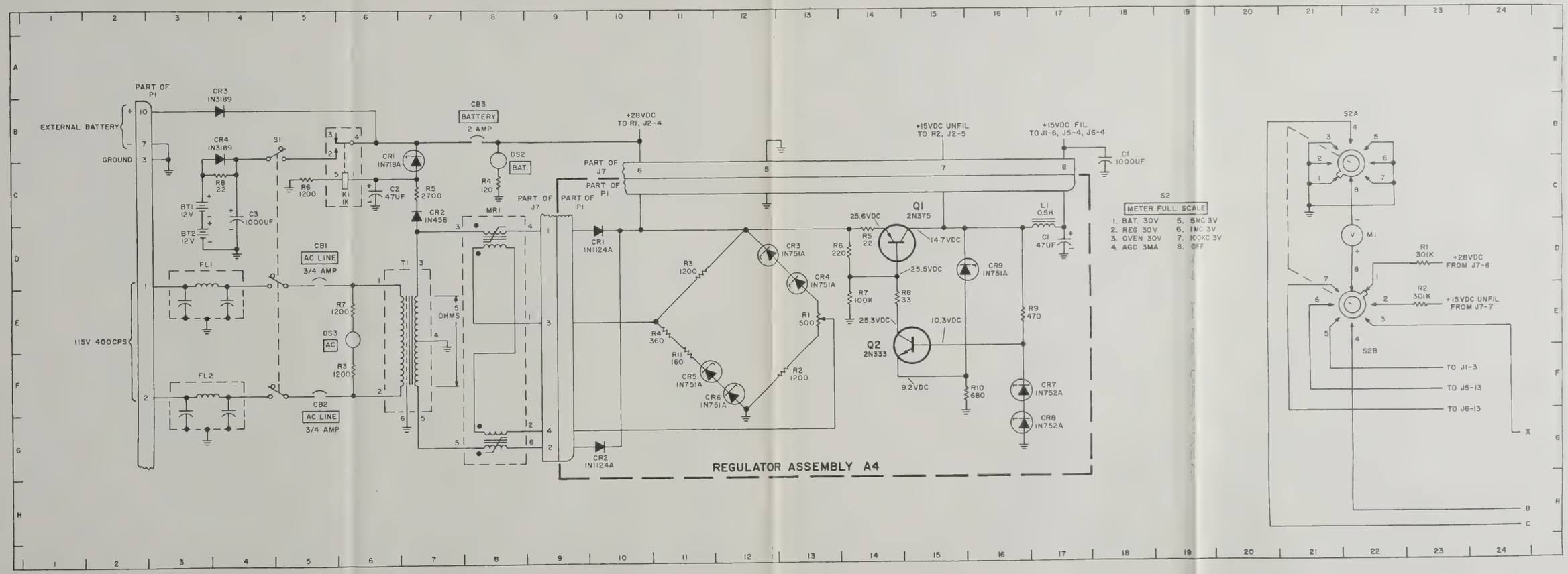


Figure 5-16. Frequency Standard O-1107/SRC-16, Schematic Diagram (Sheet 4 of 4)

SECTION 6

PARTS LIST

6-1. REFERENCE.

Refer to chapter O, volume 5

NAVSHIPS 0967-163-9040 (*Non-Registered*)

VOLUME 4

TECHNICAL MANUAL

for

RADIO SET AN/SRC-23(V)

CHAPTER M
SIGNAL COMPARATOR
CM-270/SRC-16

DEPARTMENT OF THE NAVY
NAVAL SHIP SYSTEMS COMMAND

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M1-0 to M1-2	Original	M6-1, M6-2	Original
M2-1, M3-1 to M3-3	Original		

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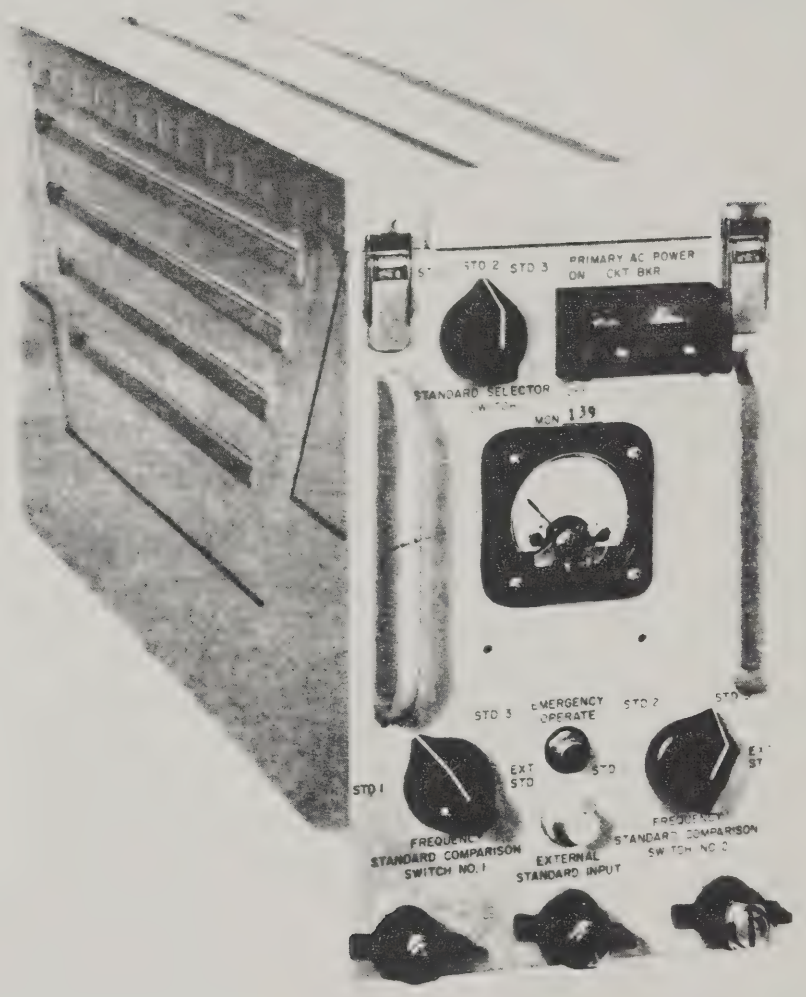


Figure 1-1. Signal Comparator CM-270/SRC-16

SECTION 1

GENERAL INFORMATION

1-1. SCOPE.

This chapter describes Signal Comparator CM-270/SCR-16 of Radio Set AN/SRC-23(V). The chapter includes general information, troubleshooting procedures, maintenance procedures, and operating procedures. Additional operating procedures are contained in chapter A, section 3 (volume 2). Installation procedures are contained in chapter A, section 2 (volume 1). Parts list information is contained in chapter O (volume 5).

This chapter is in effect upon receipt. Extracts may be made to facilitate the preparation of other Department of Defense Publications.

1-2. RELATED PUBLICATIONS.

Troubleshooting and adjustment procedures for frequency multiplier-comparator assembly A1 and rf isolation amplifier assemblies A2 and A4 are provided in the Technical Manual for Electronic Circuit Plug-in Unit Test Set AN/URM-159. Preventive maintenance schedules and procedures are provided in the Maintenance Standards Book for Radio Set AN/SRC-23(V), NavShips 0967-163-9070.

1-3. GENERAL DESCRIPTION.

Signal Comparator CM-270/SRC-16 (signal comparator) (figure 1-1) is a modular transistorized unit which compares four 100-kc inputs (two at a time). These four inputs consist of three Frequency Standard O-1107/SRC-16 signals and one external frequency standard signal. The comparison is accurate to 1 part in 10^9. When a highly stable external 100-kc frequency standard is available, each Frequency Standard O-1107/SRC-16 can be compared to the external frequency standard. If an external standard is not available, the output of each O-1107/SRC-16 can be compared with the other two units to determine the most stable of the three frequency standards. The frequency standard which provides the most stable 100-kc output is selected as the frequency standard for the AN/SRC-23(V) and any associated data terminal equipment. The 100-kc output of the selected frequency standard is amplified by rf isolation amplifier assembly A2. The rf isolation amplifier provides 40-db isolation between the 100-kc input and the two 100-kc outputs which are available. A second rf isolation amplifier assembly provides automatically switched backup in case of malfunction. The signal comparator consists of frequency mulitplier-comparator assembly A1 and rf isolation amplifier assemblies A2 and A4, which are modular plug-in assemblies mounted on chassis and power supply assembly A3.

The signal comparator is contained in a single unit designed for cabinet mounting on a shelf. Two connectors on the rear of the unit provide power and signal inputs and signal outputs from the chassis. These connectors mate to connectors in the cabinet when the chassis is inserted. The front panel contains controls to turn on power and select inputs and a meter to monitor the frequency comparison. An external standard input jack is also located on the front panel.

1-4. REFERENCE DATA.

Input frequency	100 kc.
Input level	1.0 volt.
Input impedance	50 ohms, unbalanced.
Amplifier output level	1 volt.
Amplifier output inpedance	50 ohms.
Amplifier isolation	40 db.
Frequency comparison accuracy	Detects frequency differences of 0.0001 cps at 100 kc.
Harmonic distortion	40 db below rated output.
Type of service	Continuous, unattended.
Input selection	Any two of three system inputs and one system external input for frequency comparison; any one of three system inputs for application to rf isolation amplifier.
Power requirements	115 volts, 400 cps, single phase at a maximum of 150 milliamperes.
Ambient temperature range	0° to 50°C (32° to 122°F).
Ambient humidity range	0 to 100 percent.
Overall dimensions	8-11/16 inches high, 4-13/16 inches wide, 20-9/16 inches deep.

Weight	13 pounds.
Mounting	Shelf-mounted in appropriate cabinet with all mounting devices accessible from front panel.

1-5. EQUIPMENT SIMILARITIES.

Signal Comparator CM-270/SRC-16 also is used with Communications Central AN/SRC-16 and Data Communication Group AN/TYA-19. The units are interchangeable and, with the exception of front panel markings, are identical.

SECTION 2

INSTALLATION

2-1. REFERENCE.

Signal Comparator CM-270/SRC-16 is supplied as assembly A1 of Frequency Standard Group OA-4792/SRC-23(V). Installation data for the frequency standard group is provided in system chapter A, section 2.

SECTION 3

OPERATION

3-1. FUNCTIONAL OPERATION.

The signal comparator is used to compare any two of four selectable 100-kc frequency standard inputs. Three of the frequency standards are Frequency Standard O-1107/SRC-16 units that may be part of the Radio Set AN/SRC-23(V) system. The fourth 100-kc input may be supplied by an external frequency standard connected to the front panel EXTERNAL STANDARD INPUT coaxial connector. Two of the four available 100-kc inputs are selected by FREQUENCY STANDARD COMPARISON SWITCH NO. 1 and FREQUENCY STANDARD COMPARISON SWITCH NO. 2. The difference between the two selected frequencies is indicated by the front panel comparison meter. The most accurate of the three O-1107/SRC-16 100-kc outputs is selected by the STANDARD SELECTOR SWITCH as the frequency standard for the AN/SRC-23(V) system. The selected 100-kc signal is amplified by rf isolation amplifier assembly A2, which provides 40 db of isolation between the input and outputs. If isolation amplifier assembly A2 should malfunction, rf isolation amplifier assembly A4 is automatically switched into the circuit. Under these conditions, the front panel EMERGENCY OPERATE indicator lamp lights, and external system alarm circuits are energized. A power failure also will cause the external system alarm circuits to energize. The unit is protected by two circuit breakers in the primary power line.

3-2. DESCRIPTION OF CONTROLS AND INDICATORS. (Refer to figure 3-1 and table 3-1.)

3-3. OPERATING PROCEDURES.

a. FREQUENCY STANDARD COMPARISON. - Before attempting to compare the frequency standard outputs, a reference frequency standard must be established. The 100-kc reference frequency may be provided by an external frequency standard connected to the front panel EXTERNAL STANDARD INPUT connector or by one of the three Frequency Standard O-1107/SRC-16 units. If an external frequency standard is used for a reference, be sure the external unit is accurately calibrated and capable of high stability operation. If one of the O-1107/SRC-16 units is to be used as a reference, be sure the unit meets the requirements of a primary frequency standard as described in paragraph 5-2, chapter L, section 5 (volume 4) of the technical manual.

(1) Set FREQUENCY STANDARD COMPARISON SWITCH NO. 1 to select the reference frequency standard 100-kc input.

(2) Set FREQUENCY STANDARD COMPARISON SWITCH NO. 2 to select the frequency standard which is to be compared with the reference frequency standard.

(3) Observe the front panel comparison meter indication for 100 seconds. Start timing as the needle swings past the reference mark. Count the number of times the needle swings past the reference mark in the same direction within the 100-second time period.

(4) One cycle is completed each time the needle passes the reference mark in the same direction. The number of cycles completed within 100 seconds is equal to the frequency difference between the two signals in parts per 10^9. For example, if nine cycles are completed in 100 seconds, the frequency difference is nine parts in 10^9.

b. FREQUENCY STANDARD SELECTION.

(1) Compare each of the internal frequency standards with the external reference frequency standard.

(2) Set the STANDARD SELECTOR SWITCH to select the most accurate internal frequency standard as the frequency standard for the Radio Set AN/SRC-23(V) system.

3-4. EMERGENCY OPERATION.

If rf isolation amplifier assembly A2 is not functioning properly, the EMERGENCY OPERATE indicator lamp lights. Inform maintenance personnel, but continue operation. The 100-kc signal outputs will be

provided automatically through rf isolation amplifier assembly A4. In the event of failure of both rf isolation amplifiers or loss of internal power (indicated by external alarms), turn PRIMARY AC POWER CKT BKR to OFF position; remove dust cover; place COMPARATOR BYPASS switch to ON position; replace the dust cover; and restore power to the unit. Operation of COMPARATOR BYPASS switch will allow the selected 100-kc frequency standard signal to bypass rf isolation amplifier assemblies A2 and A4.

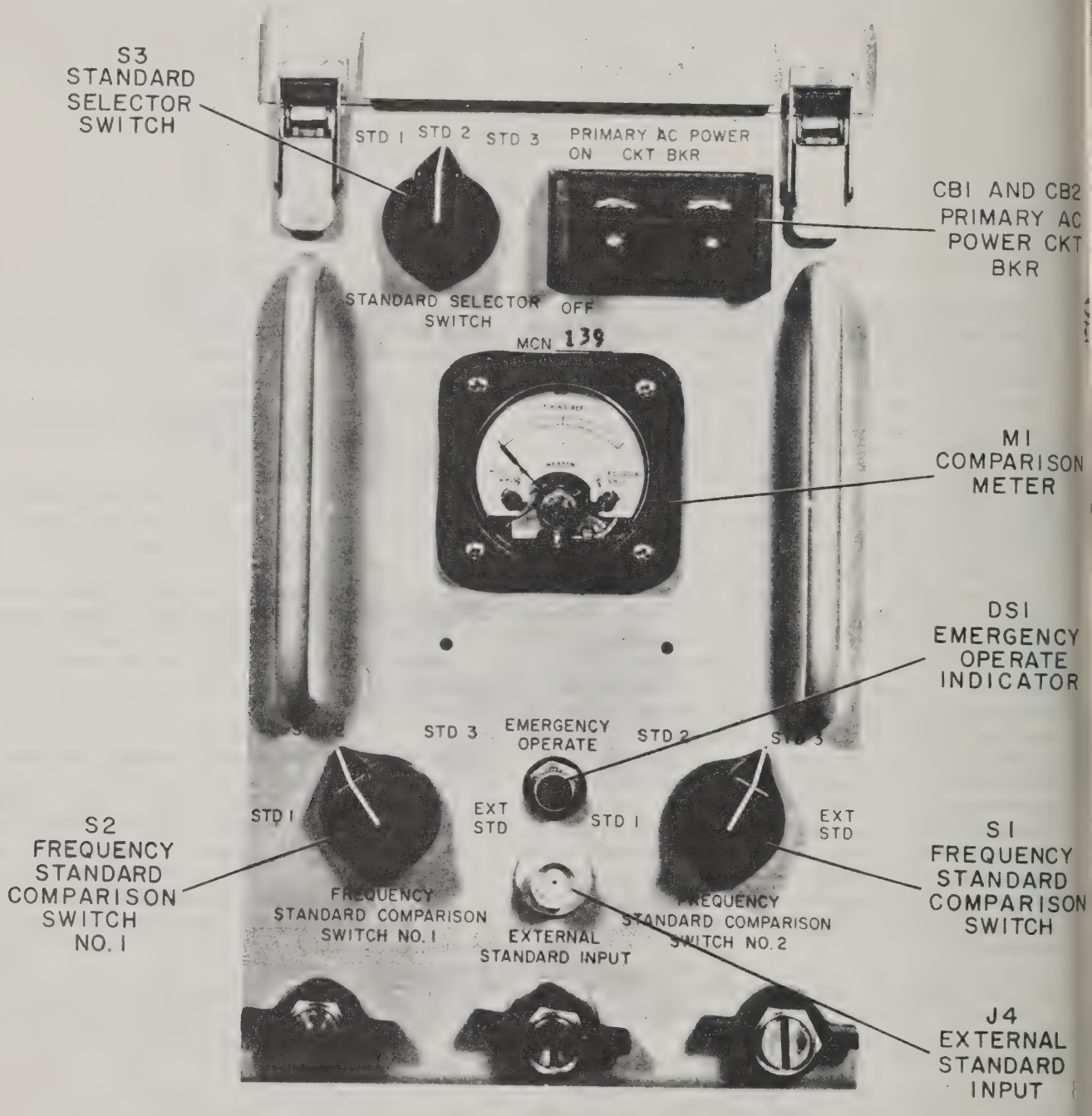


Figure 3-1. Signal Comparator CM-270/SRC-16, Operating Controls and Indicators

TABLE 3-1. CONTROLS AND INDICATORS

CONTROL OR INDICATOR	FUNCTION
PRIMARY AC POWER CKT BKR	Protects both sides of the 115-volt primary line; acts as power on-off switch.
FREQUENCY STANDARD COMPARISON SWITCH NO. 1	Selects one of four available frequency sources for comparison with frequency source selected by FREQUENCY STANDARD COMPARISON SWITCH NO. 2; includes EXT STD position for selection of input to front panel EXTERNAL STANDARD INPUT jack.
FREQUENCY STANDARD COMPARISON SWITCH NO. 2	Provides same switching functions as FREQUENCY STANDARD COMPARISON SWITCH NO. 1.
Comparison meter	Indicates frequency difference of inputs selected by FREQUENCY STANDARD COMPARISON SWITCH NO. 1 and FREQUENCY STANDARD COMPARISON SWITCH NO. 2.
STANDARD SELECTOR SWITCH	Selects any one of three frequency standards to be fed to the rest of the system through the two rf isolation amplifier subassemblies.
EXTERNAL STANDARD INPUT coaxial connector	Allows any external standard to be compared with any of the three frequency standards available from a rear chassis connector.
EMERGENCY OPERATE indicator	Comes on if rf isolation amplifier assembly A2 is not providing an output.

SECTION 4

TROUBLESHOOTING

4-1. LOGICAL TROUBLESHOOTING.

The signal comparator is a modularized unit and therefore must be fault-analyzed on the module level and then on the circuit level. Before any internal tests are performed, however, the primary power check described in chapter A, section 3 (volume 2) should be performed. Frequency multiplier-comparator assembly A1 and rf isolation amplifier assemblies A2 and A4 are tested with Electronic Circuit Plug-in Unit Test Set AN/URM-159. Figures 4-1 and 5-8 are provided for module and circuit testing.

Troubleshooting for this equipment should be based on the six steps of logical troubleshooting. These six steps are as follows:

a. SYMPTOM RECOGNITION. - This is the first step in the troubleshooting procedure. All equipment troubles are not the direct result of component failure. Therefore, a trouble in an equipment is not always easy to recognize, since all conditions of less than peak performance are not always apparent. This type of equipment trouble is usually discovered while accomplishing preventive maintenance procedures, such as the POMSEE checks. It is important that the not so apparent troubles, as well as the apparent troubles, be recognized.

b. SYMPTOM ELABORATION. - After an equipment trouble has been recognized, all the available aids designed into the equipment should be used to further elaborate the original trouble symptom. Use of equipment front panel controls and other built-in indicating or testing aids should provide a better identification of the original trouble symptom. Checking or otherwise manipulating the operating controls also may eliminate the trouble.

c. LISTING PROBABLE FAULTY FUNCTION. - The next logical step in troubleshooting is to formulate a number of educated guesses as to the cause and likely location (functional section) of the trouble. The educated guesses are mental decisions which are based on knowledge of the equipment operation, a full identification of the trouble symptom, and information supplied by the technical manual. The overall equipment functional discussion and block diagram should be referred to when selecting possible faulty functional sections.

d. LOCALIZING THE FAULTY FUNCTION. - For the greatest efficiency in localizing trouble, the functional sections which have been selected by the educated-guess method should be tested in the order that will require the least amount of time to find the faulty section. This requires a mental selection to determine which section to test first, i.e., quick sensory checks to eliminate possible trouble. The selection should be based on two factors: the validity of the educated guesses and the difficulties in making the necessary tests to check the functional section. Waveforms or other pertinent indications are included at significant checkpoints on servicing block diagrams to serve as aids in isolating the faulty section. Also, the test data supplied to augment the functional description and servicing block diagram of a functional section provides such information as pertinent control settings, critical adjustments, test equipment lists, and other necessary information which will aid in testing the functional section.

e. LOCALIZING TROUBLE TO CIRCUIT. - After the faulty functional section has been isolated, it should be replaced by a workable spare. Troubleshooting and repair of the functional sections are explained in the Technical Manual for Electronic Circuit Plug-in Unit Test Set AN/URM-159.

f. FAILURE ANALYSIS. - After the trouble has been located and corrected, review the steps taken and decide why the trouble affected the equipment in the manner it did. This step is taken to determine if other circuit elements were responsible for the malfunction.

4-2. OVERALL FUNCTIONAL DESCRIPTION.

The signal comparator compares the output frequency of two of four signal inputs and provides selection of an isolated 100-kc output from one of three Frequency Standard O-1107/SRC-16 inputs; the selected frequency standard is applied to the AN/SRC-23(V) system. Refer to the servicing block diagram, figure 4-1. Any two of the four frequency standard inputs may be selected for comparison by frequency multiplier-comparator assembly A1. The difference frequency between the two signals is indicated by the front panel comparison meter. A comparison accuracy of 1 part in 10^9 can be obtained by a 100-second sampling period. Any one of the three O-1107/SRC-16 equipments can be selected as the primary frequency standard for the AN/SRC-23(V) system. Rf isolation amplifier assembly A2 provides 40-db isolation between the selected frequency standard and the outputs to the system. If a malfunction occurs in rf isolation amplifier assembly A2, the output of rf isolation amplifier A4 is automatically switched into the sytem. If both rf isolation amplifier assemblies should malfunction, the selected 100-kc frequency standard output can be switched to bypass the rf isolation amplifiers. The signal comparator provides alarm outputs to the system, which indicate a malfunction of rf isolation amplifier assembly A2 or both rf isolation amplifier assemblies A2 and A4.

4-3. FREQUENCY MULTIPLIER-COMPARATOR ASSEMBLY A1.

a. FUNCTIONAL DESCRIPTION. - Frequency multiplier-comparator assembly A1 contains two

identical multiplier circuits and a twin-T mixer with a rectifier circuit. Each multiplier circuit includes a x4 multiplier stage and two x5 multiplier stages. The 100-kc inputs to each multiplier circuit produce 10-mc outputs which are applied to the twin-T mixer. When the input signal frequencies differ slightly, the phase relationship of the 10-mc output signals changes. When the 10-mc signals are in phase, the twin-T mixer produces an output which is rectified and applied to comparison meter A3M1. When the 10-mc signals are out of phase, no output is produced, and the meter indication decreases. Thus, as the phase relationship between the different frequencies changes, the needle moves above and below the reference mark. The number of times the needle passes the reference mark in the same direction within 100 seconds is equal to the number of parts in 10^9 that the two 100-kc frequency standards differ.

b. TEST DATA. - The frequency multiplier-comparator assembly A1 output is applied to the front panel comparison meter. To isolate trouble within frequency multiplier-comparator assembly A3, apply the same 100-kc signal to both multiplier inputs. This is accomplished by setting FREQUENCY STANDARD COMPARISON SWITCH NO. 1 and FREQUENCY STANDARD COMPARISON SWITCH NO. 2 to the same setting. The comparison meter should indicate nearly full scale. Then apply the 100-kc signal to only one of the multiplier circuits. The comparison meter should indicate only one-third to one-half of full scale. Repeat this test for the opposite multiplier circuit. If normal comparison meter indications are not observed, the trouble is caused by circuits within the frequency multiplier-comparator, and this trouble should be analyzed using the troubleshooting procedures in the Technical Manual for Electronic Circuit Plug-in Unit Test Set AN/URM-159. Table 4-1 lists normal frequency multiplier-comparator test-point voltages.

TABLE 4-1. FREQUENCY MULTIPLIER-COMPARATOR TEST-POINT VOLTAGES

BLOCK DIAGRAM REFERENCE	TEST POINTS	VOLTAGE RMS VOLTS
A	TP4, TP8	5 ±2
B	TP3, TP7	4.5 ±2
C	TP2, TP6	7.5 ±2

4-4. RF ISOLATION AMPLIFIERS AND RELAY CIRCUITS.

a. FUNCTIONAL DESCRIPTION. - Rf isolation amplifiers A2 and A4 are identical assemblies. STANDARD SELECTOR SWITCH A3S3 selects the input to both assemblies from the three available O-1107/SRC-16 100-kc sources. Each rf isolation amplifier consists of three subassemblies. The two amplifier subassemblies contain a driver amplifier and a push-pull output amplifier stage. The amplifier subassemblies provide 40 db of isolation between the input and the two outputs. The third subassembly contains a buffer amplifier and a rectifier circuit which provides a dc output when a 100-kc input is applied and the amplifier subassemblies are functioning properly. If a malfunction occurs or the 100-kc signal is interrupted, no dc output voltage is provided. In the absence of a dc output from rf isolation amplifier assembly A2, relay A3K1 deenergizes. As a result, EMERGENCY OPERATE indicator lamp A3DS1 lights, and emergency relay A3K3 deenergizes. Under these conditions, the 100-kc outputs of rf isolation amplifier assembly A4 are switched over to provide 100-kc outputs at A3P2-8 and 10. When emergency relay A3K3 deenergizes, ground is disconnected from alarm line 1 to indicate emergency operation is in effect. Relay A3K2 maintains a ground on alarm line 2 to indicate that rf isolation amplifier assembly A4 is functioning properly. If this backup isolation amplifier should also fail, ground is disconnected from alarm line 2 to indicate that no 100-kc signal is available at the signal comparator output. Under this emergency condition, the COMPARATOR BYPASS switch should be set to ON. As a result, the selected 100-kc reference frequency bypasses both rf isolation amplifier assemblies and is applied to the output at A3P2-10. The EMERGENCY OPERATE indicator lamp remains on, and alarm line 1 continues to provide an emergency operation indication. Alarm line 2 is grounded at the COMPARATOR BYPASS switch to indicate a 100-kc signal is available at the signal comparator output.

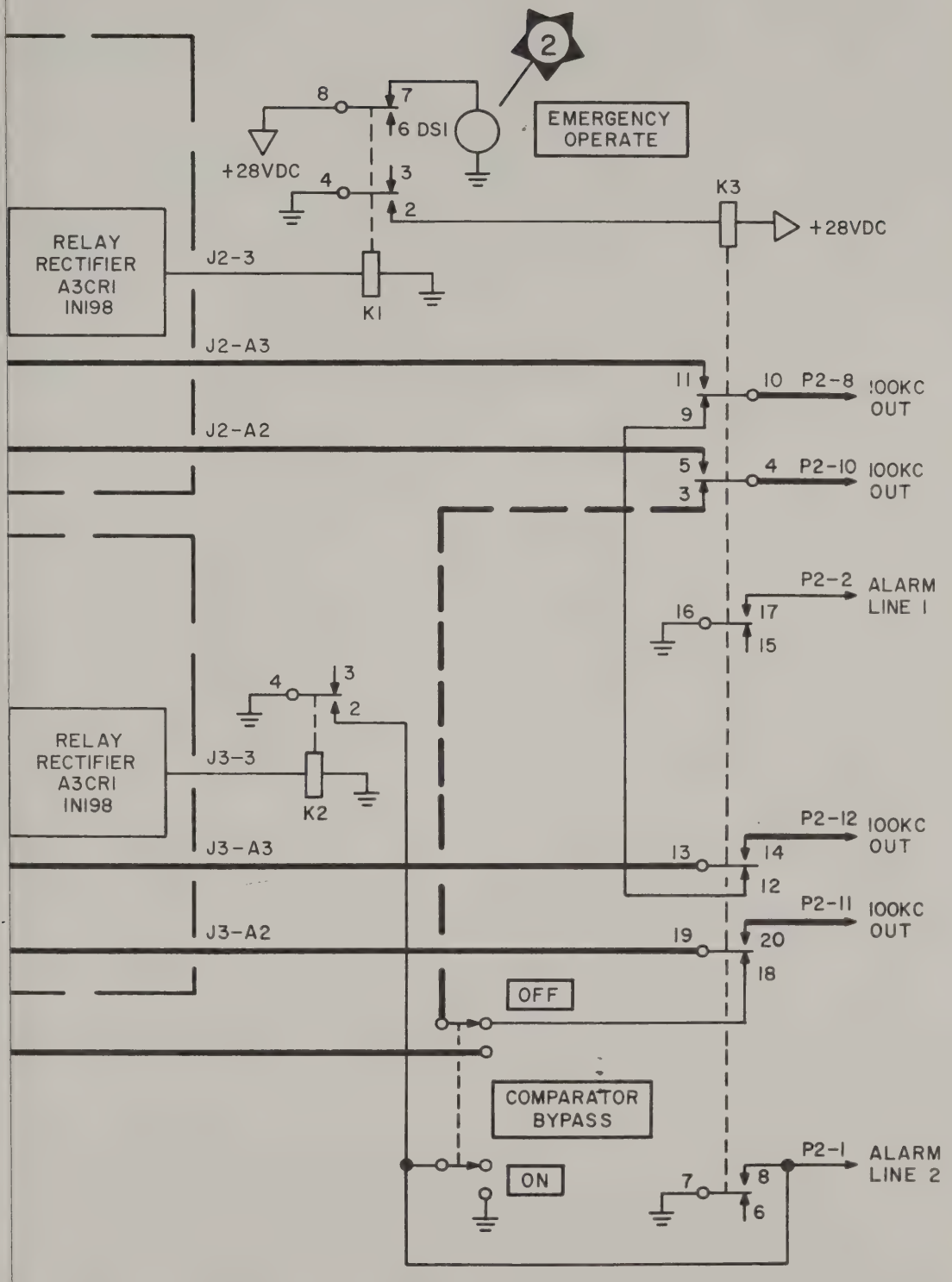
b. TEST DATA. - A malfunction in rf isolation amplifier assembly A2 or A4 is usually indicated when the EMERGENCY OPERATE indicator lamp lights. The rf isolation amplifiers are tested by Electronic Circuit Plug-in Unit Test Set AN/URM-159. To isolate the cause of trouble to either of these assemblies, check the test-point voltages at the 100-kc outputs designated D and E on the servicing block diagram, figure 4-1. When a 1-volt rms, 100-kc input signal is applied, the normal test-point voltage should be 1 volt rms. The assemblies may be interchanged, if necessary, to further isolate the cause of trouble. If both rf isolation amplifier assemblies are tested and found to be operating properly, check the operation and circuitry of relays A3K1 and A3K2 and emergency relay A3K3 to locate the cause of trouble.

4-5. POWER SUPPLY CIRCUITS.

a. FUNCTIONAL DESCRIPTION. - The signal comparator operates on 115-volt, 400-cps single-phase primary power which is applied to transformer A3T1 through PRIMARY AC POWER CKT BKR A3CB1 and A3CB2. A full-wave rectifier consisting of diodes

A3CR1 through A3CR4 provides a 28-volt dc output. The +28 volt-dc output is applied to relays A3K3 and to the EMERGENCY OPERATE indicator lamp when relay A3K1 is deenergized. Zener diode A3CR5 provides regulated +18 volts dc which is filtered by A3L1 and A3C2. The filtered +18 volts dc is applied to frequency multiplier-comparator assembly A1 and rf isolation amplifier assemblies A2 and A4 as B+ voltage.

b. TEST DATA. - The only indication of disruption of power, in addition to activation of PRIMARY AC POWER CKT BKR to OFF position, is that alarm lines 1 and 2 will not be grounded (indicating a fault to external circuits), but EMERGENCY OPERATE indicator lamp will not light. A short circuit in zener diode A3CR5 causes a fault signal on alarm lines 1 and 2 and lights the EMERGENCY OPERATE indicator lamp.



e 4-1. Signal Comparator CM-270/SRC-16, Servicing Block Diagram

A3CR1 through A3CR4 provides a 28-volt dc output. The +28 volt-dc output is applied to relays A3K3 and to the EMERGENCY OPERATE indicator lamp when relay A3K1 is deenergized. Zener diode A3CR5 provides regulated +18 volts dc which is filtered by A3L1 and A3C2. The filtered +18 volts dc is applied to frequency multiplier-comparator assembly A1 and rf isolation amplifier assemblies A2 and A4 as B+ voltage.

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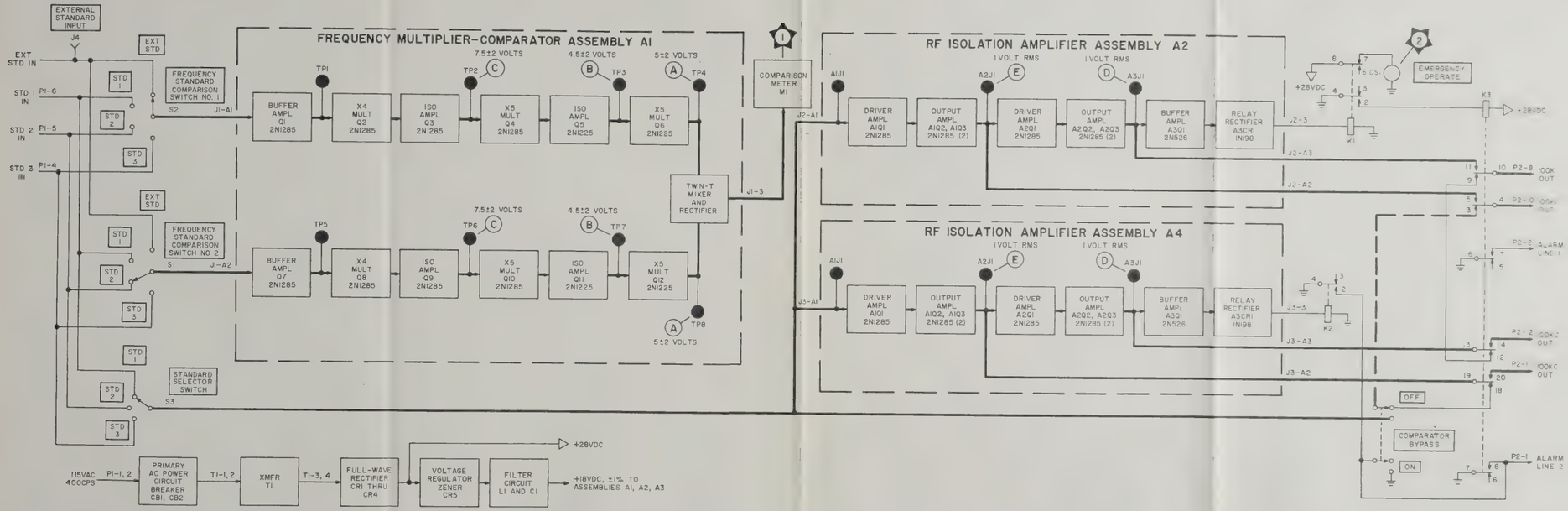

Figure 4-1. Signal Comparator CM-270/SRC-16, Servicing Block Diagram

SECTION 5

MAINTNENANCE

5-1. PREVENTIVE MAINTENANCE.

Refer to the Maintenance Standards Book for Radio Set AN/SRC-23(V), NavShips 0967-163-9070.

5-2. ALIGNMENT AND ADJUSTMENT.

a. GENERAL. - The alignment procedures for frequency multiplier-comparator assembly A1 and rf isolation amplifier assemblies A2 and A4 are included in the Technical Manual for Electronic Circuit Plug-in Unit Test Set AN/URM-159.

b. METER DEFLECTION ADJUSTMENT.

(1) Extend signal comparator from mounting shelf with extender cable supplied with maintenance kit. Remove the top dust cover.

(2) Connect 100-kc frequency standard to front panel EXTERNAL STANDARD INPUT coaxial connector J4, and apply 100-kc input signal.

(3) Set FREQUENCY STANDARD COMPARISON SWITCH NO. 1 to EXT STD position. Set FREQUENCY STANDARD COMPARISON SWITCH NO. 2 to any other position.

(4) Adjust A1R23 (figure 5-1) on frequency multiplier-comparator assembly A1 for one-third of (but less than one-half) full scale deflection on front panel comparison meter.

(5) Set FREQUENCY STANDARD COMPARISON SWITCH NO. 2 to EXT STD position. The comparison meter needle should swing past the reference mark, but should not be pegged. If the needle pegs, decrease the meter indication by resetting resistor A1R23.

5-3. REPAIR.

a. REMOVAL OF SIGNAL COMPARATOR FROM CABINET. - Remove the signal comparator from the cabinet by loosening the wingnuts on two outside collet fasteners, turning the wingnut on the center extracter screw counterclockwise to loosen, and pulling unit out of cabinet. Power and signal connectors will be disconnected at the rear of the unit when it is pulled out of the cabinet.

Remove the top dust cover by disengaging the two finger-actuated buckles at the top front of the unit and slipping the cover off the two dowel pins located at the top rear. Remove the bottom cover by loosening the 16 quarter-turn fasteners which secure the cover to the unit.

b. REMOVAL OF ASSEMBLIES. - Modular assemblies may be removed from the signal comparator by loosening the four holding screws. The assemblies pull out, and all electrical connections are automatically disconnected. To remove the assembly dust covers, loosen the two screws at the top of the assembly, and pull cover off by grasping the ring at the top.

c. PRINTED CIRCUIT BOARD REPAIR. - Parts mounted on the printed circuit boards are bonded to the boards to protect them from damage by humidity and moisture. This bonding (postcoating) also serves to protect the parts against excessive vibration in service. If the repair process requires that a part be removed from the board and replaced with another part, the following procedure should be used. The bonding agent to be used in recoating the boards is a postcoating material, Dennis 1169 (FSN 5970-738-5960). This material consists of two parts, Dennis 1169A and 1169B, which must be mixed.

(1) Inspect the board for evidence of burns, scorches, heat damage, corroded metal parts or terminals, or delamination of the base laminate. If any of these defects are evident, replace the entire board rather than attempting repair. If the board appears repairable, proceed to step 2.

(2) Remove the designated part from the printed board by destroying the protective postcoating with a hot soldering iron; then unsolder the part, and lift it off the board with a pair of long-nosed pliers.

CAUTION

Do not use soldering irons rated above 100 watts on boards bearing transistors, Cerafil capacitors, or other heat sensitive components. Also, exercise care when removing components from printed circuit boards so that the circuitry is not damaged.

(3) If necessary, remove the excess solder from the joint with a soldering iron.

(4) Insert the new wire or component lead in the correct tubelet, and clinch the wire over the tubelet.

(5) Apply solder to the joint using any rosin flux core solder conforming to QQ-S-571 type AR or 63/37 (tin-lead) solid wire solder and rosin flux. Do not use a solder that has a core of hydrazine, acid, or other unapproved flux. Do not keep the iron on the joint longer than necessary to complete the solder flow throughout the joint.

(6) Inspect the solder joint to be sure the solder completely covers metal surfaces, component leads, tubelets, eyelets, or terminals which have been soldered and that there is a smooth continuous fillet of solder between tubelet flares and the circuitry. Also, note that there are no cold or fractured solder joints or nonadherence of solder to metal and no excess solder globules, peaks, strings, or bridges of solder between adjacent parts or circuits.

(7) Clean the joint to remove the flux, using a medium-bristled brush and a small amount of

organic solvent, such as trichloroethylene, toluol, or proprietary solvents (such as Freon TMC). Remove as much of the melted plastic and flux from the soldered area as possible. Remove excess solvent and dissolved flux with absorbent material.

Note

Use solvent sparingly, since the postcoating also will be dissolved. Apply a small amount to the area of the solder joint only.

(8) Mix together one part of Dennis 1169A liquid and one part Dennis 1169B liquid in a stainless steel, wax-free paper or polyethylene container, and stir with a stainless steel spatula or equivalent. Mix thoroughly.

(9) Apply the Dennis 1169 mixture to the newly soldered joint (or joints), covering all areas where the original coating was damaged and any new components which were added. Use a soft-bristled brush to apply the Dennis 1169.

(10) Allow the newly coated boards to dry to a tack-free condition (approximately 2 hours) before reassembling the module. The final cure will take approximately 7 days at room temperature or 1 hour at +60°C (+140°F). The equipment may be operated during the curing period.

d. PARTS LOCATION ILLUSTRATIONS. Refer to figures 5-1 through 5-7 for parts locations.

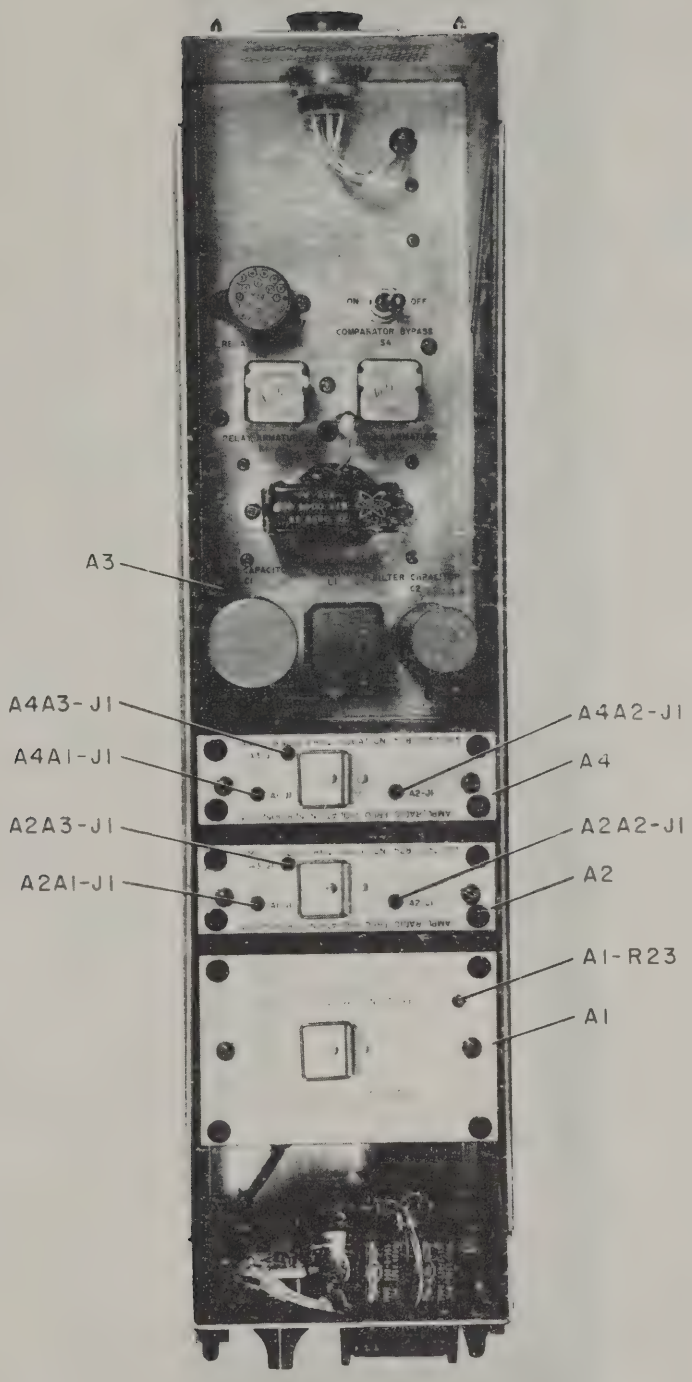

Figure 5-1. Top View, Assembly and Test-Point Locations

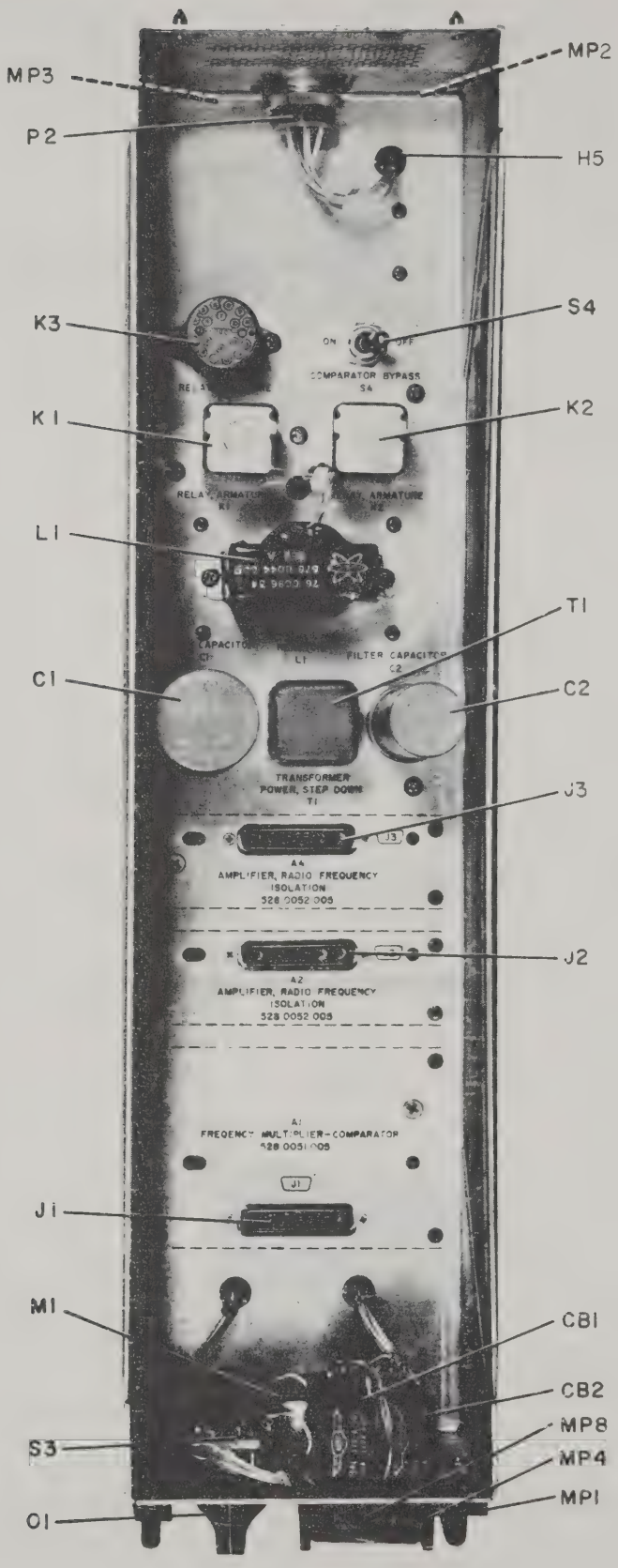

Figure 5-2. Power Supply and Chassis Assembly A3, Top View, Parts Location

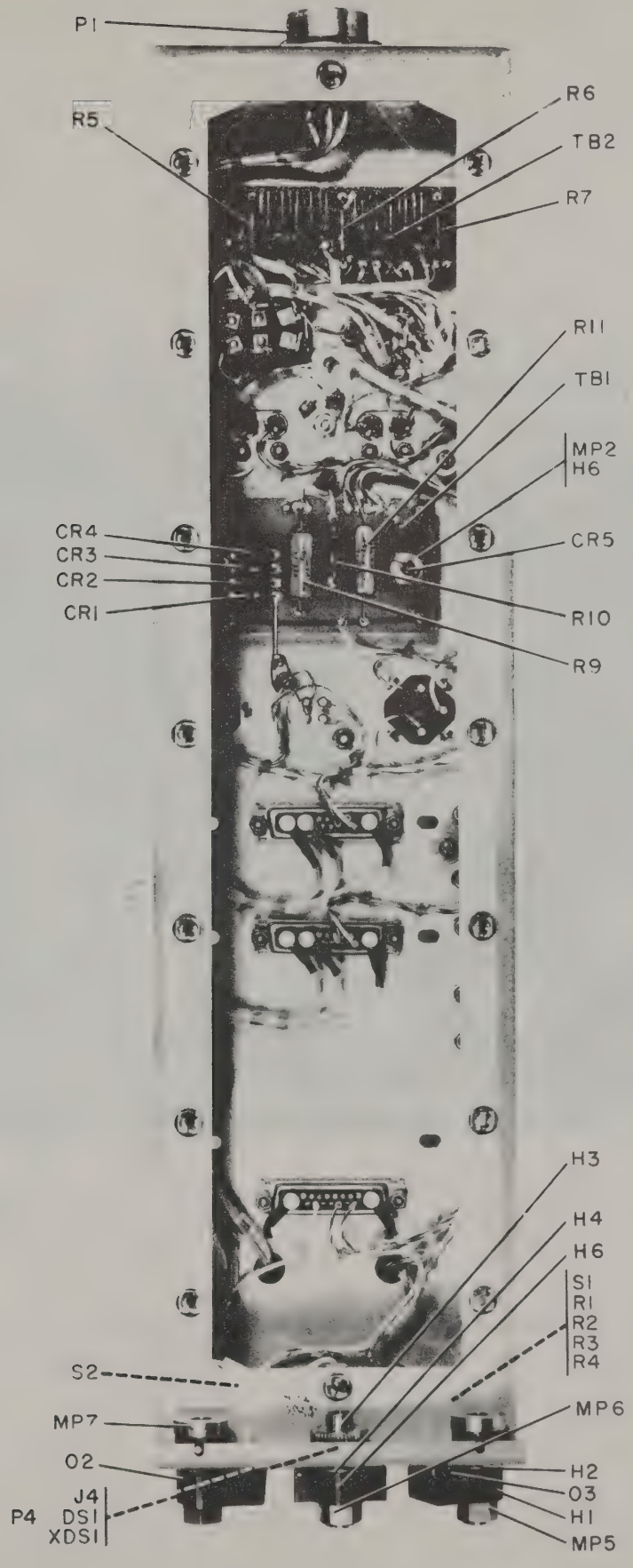

Figure 5-3. Power Supply and Chassis Assembly A3, Bottom View, Parts Location

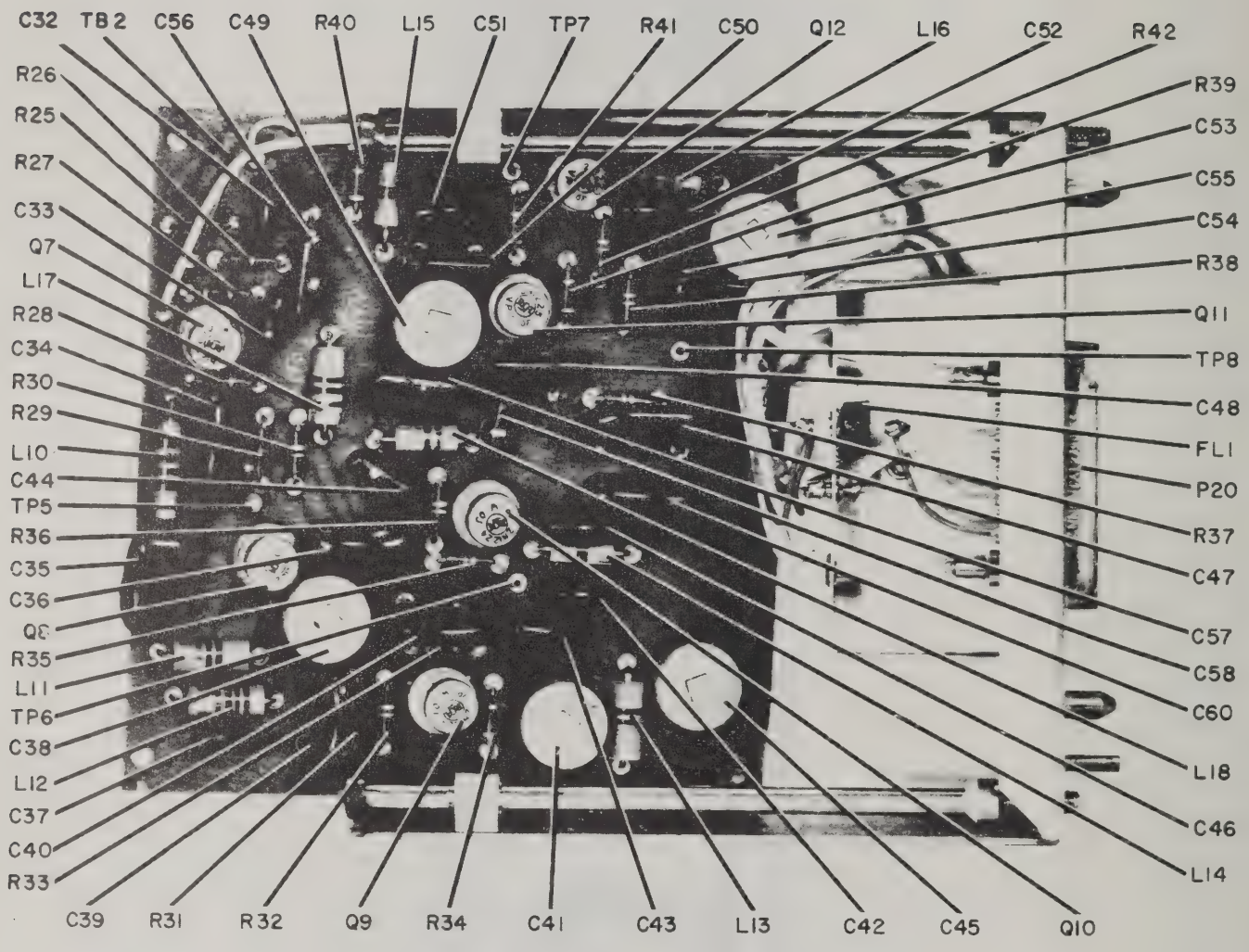

Figure 5-4. Frequency Multiplier-Comparator Assembly A1, Parts Location

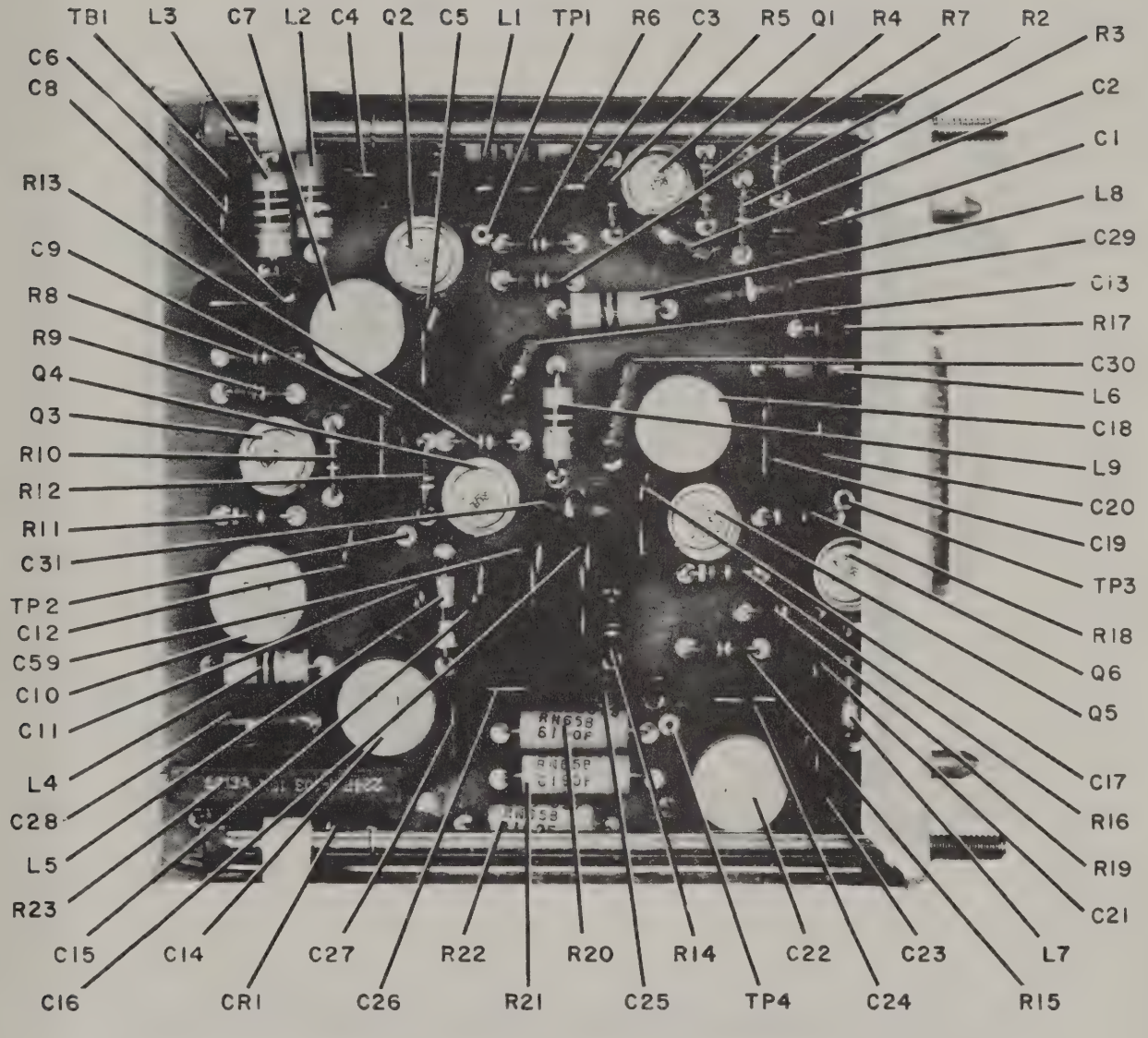

Figure 5-5. Frequency Multiplier-Comparator Assembly A1, Parts Location

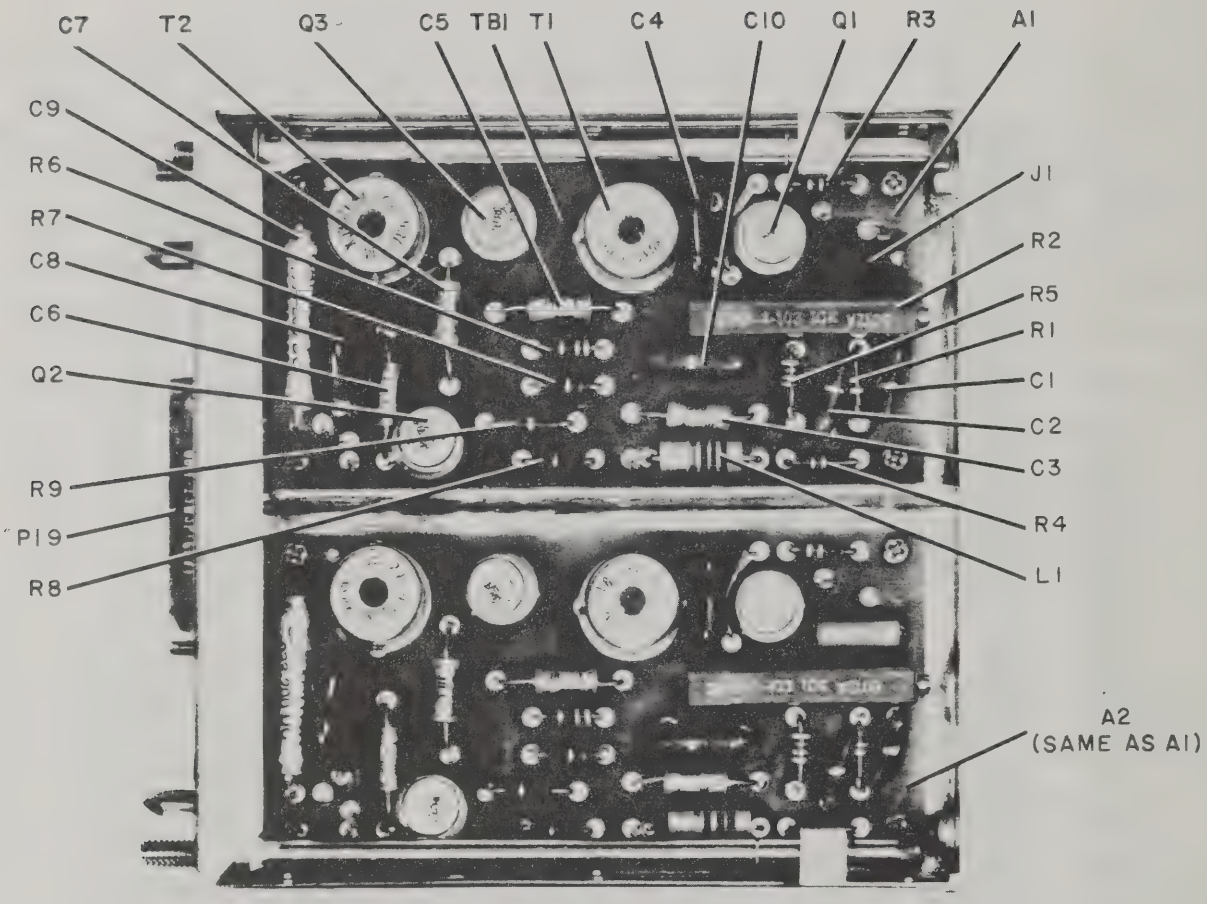

Figure 5-6. RF Isolation Amplifier Assemblies A2 and A4, Parts Location

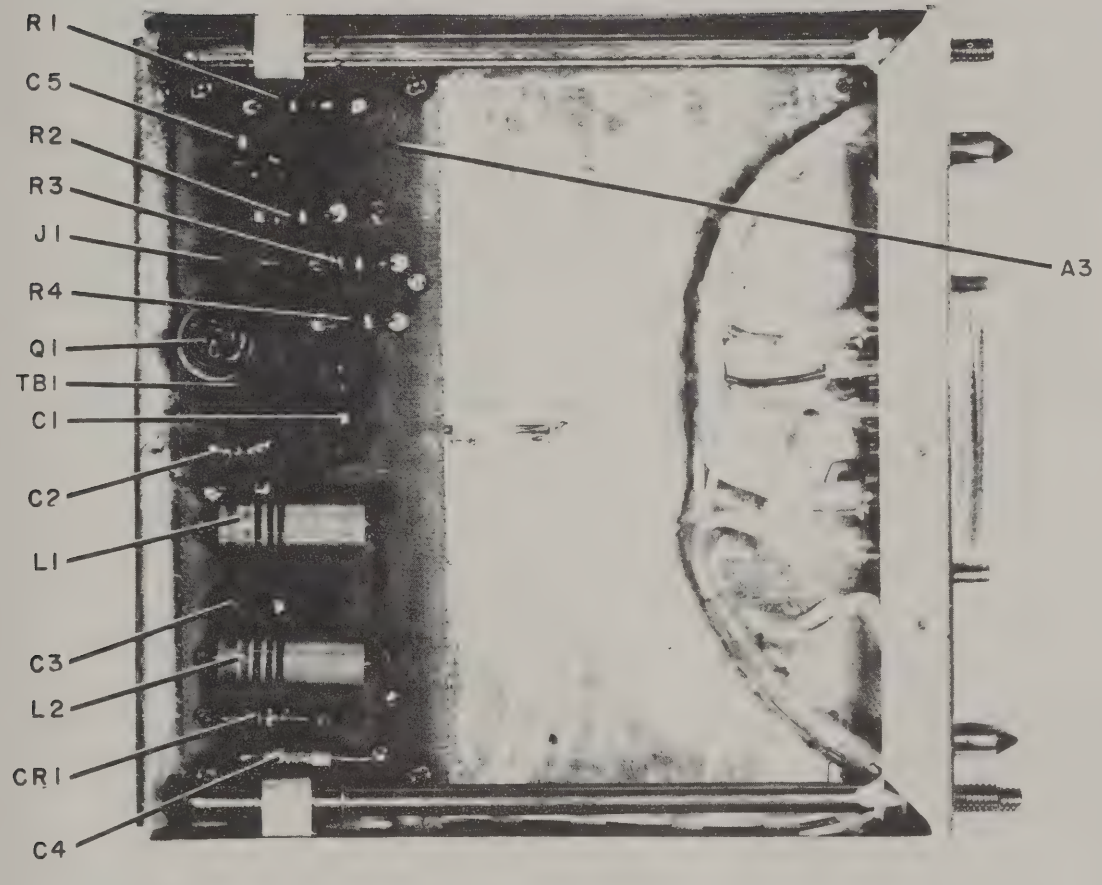

Figure 5-7. RF Isolation Amplifier Assemblies A2 and A4, Parts Location

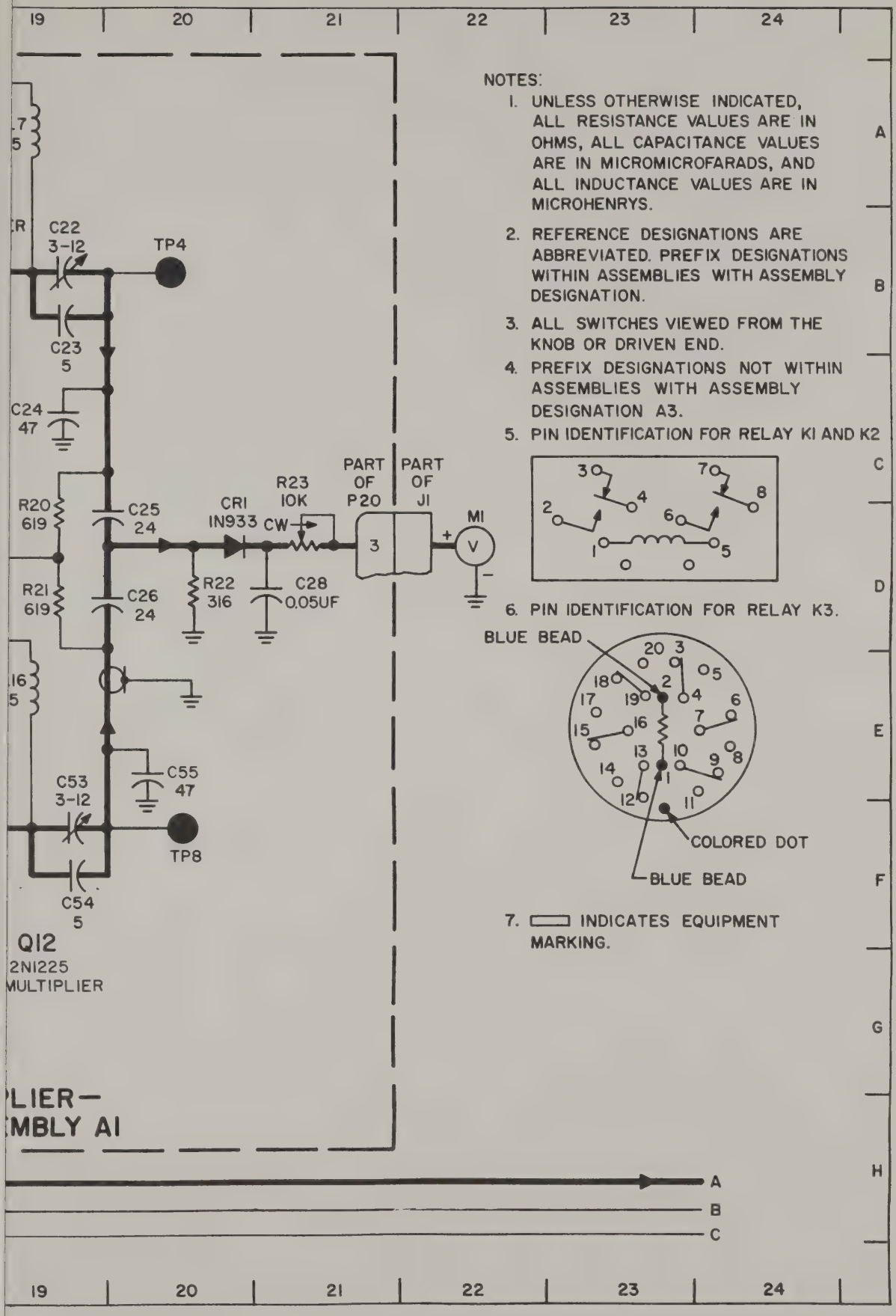

Figure 5-8. Signal Comparator CM-270/SRC-16, Schematic Diagram (Sheet 1 of 2)

REF DESIG	LOC	REF DESIG	LOC	REF DESIG	LOC	REF DESIG	LOC
C1A	4H	A1C10	13A	A1L1	9A	A1R21	20D
C1B	30F	A1C11	13B	A1L2	10A	A1R22	20D
C2	5H	A1C12	14B	A1L3	11B	A1R23	21D
CB1	2H	A1C13	15C	A1L4	13A	A1R25	7E
CB2	2G	A1C14	15A	A1L5	15A	A1R26	7G
CR1	3G	A1C15	15B	A1L6	18A	A1R27	8G
CR2	4G	A1C16	16C	A1L7	19A	A1R28	8E
CR3	4G	A1C17	17C	A1L8	11D	A1R29	9G
CR4	3G	A1C18	17A	A1L9	15D	A1R30	10G
CR5	5H	A1C19	17B	A1L10	9E	A1R31	12E
DS1	44C	A1C20	18B	A1L11	10E	A1R32	12G
J1	6B	A1C21	18C	A1L12	11F		
	22D	A1C22	19B	A1L13	13E		
J2	25B	A1C23	19B	A1L14	15E		
	43B	A1C24	19C	A1L15	18E		
J3	30G	A1C25	20D	A1L16	19E		
	25G	A1C26	20D	A1L17	11G		
J4	2B	A1C27	19D	A1L18	15G		
K1	44B	A1C28	21D	A1P20	6B		
K2	31F	A1C29	10D		21C		
K3	45B	A1C30	11D	A1Q1	8C		
L1	5G	A1C31	16D	A1Q2	10B		
M1	22D	A1C32	7F	A1Q3	13B		
P1	1H	A1C33	8G	A1Q4	15B		
P2	47C	A1C34	9F	A1Q5	17B		
	1D	A1C35	9G	A1Q6	19B		
P4	1B	A1C36	10G	A1Q7	8F		
R1	3G	A1C37	11F	A1Q8	10F		
R2	2F	A1C38	11F	A1Q9	13F		
R3	2E	A1C39	12F	A1Q10	15F		
R4	2D	A1C40	13G	A1Q11	17F		
R5	46F	A1C41	13F	A1Q12	19F		
R6	46G	A1C42	13F	A1R2	7A		
R7	46D	A1C43	14F	A1R3	7C		
R9	4G	A1C44	15G	A1R4	8C		
R10	4H	A1C45	15E	A1R5	9A		
R11	4G	A1C46	15F	A1R6	9C		
S1	5E	A1C47	15F	A1R7	10C		
S2	5C	A1C48	17G	A1R8	12A		
S3	5A	A1C49	17E	A1R9	12C		
S4	42E	A1C50	17F	A1R10	13C		
T1	2G	A1C51	17F	A1R11	13A		
A1C1	7C	A1C52	18G	A1R12	14C		
A1C2	8C	A1C53	19F	A1R13	15C		
A1C3	9C	A1C54	19F	A1R14	16B		
A1C4	9C	A1C55	20E	A1R15	16C		
A1C5	9C	A1C56	11H	A1R16	17C		
A1C6	11B	A1C57	11H	A1R17	17A		
A1C7	11C	A1C58	16H	A1R18	18C		
A1C8	12C	A1C60	16G	A1R19	19C		
A1C9	13C	A1FL1	7G	A1R20	20D		

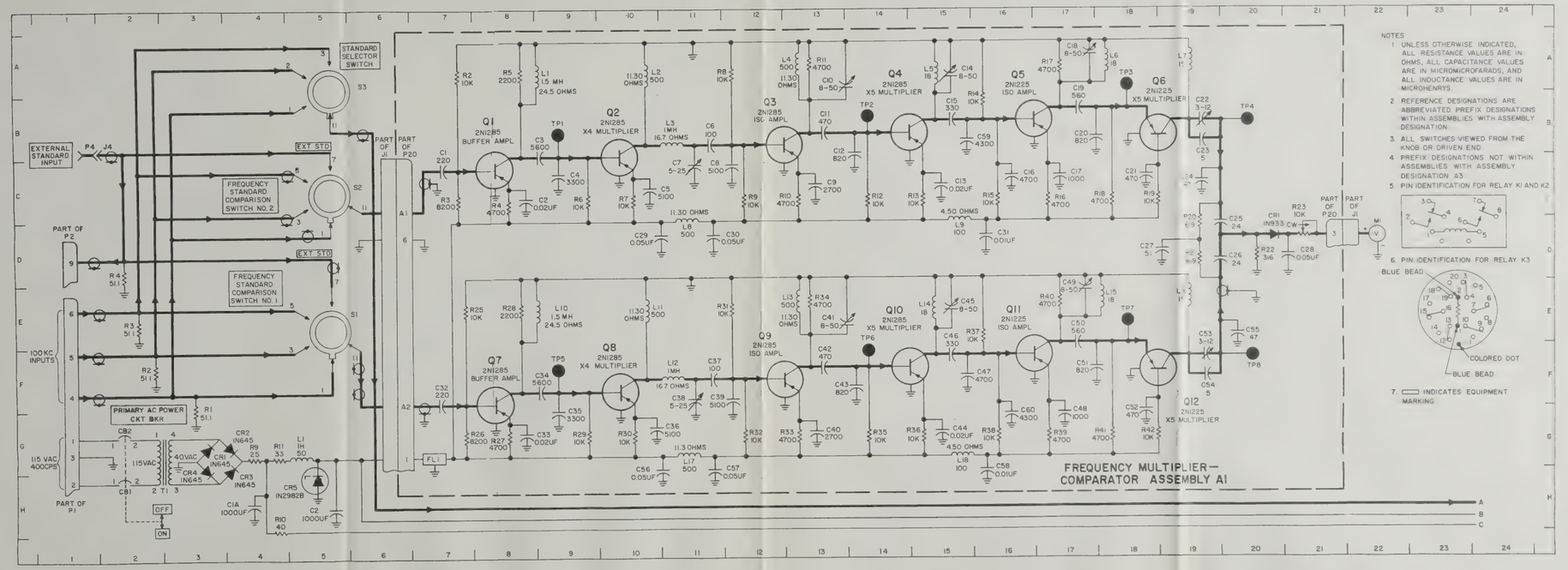

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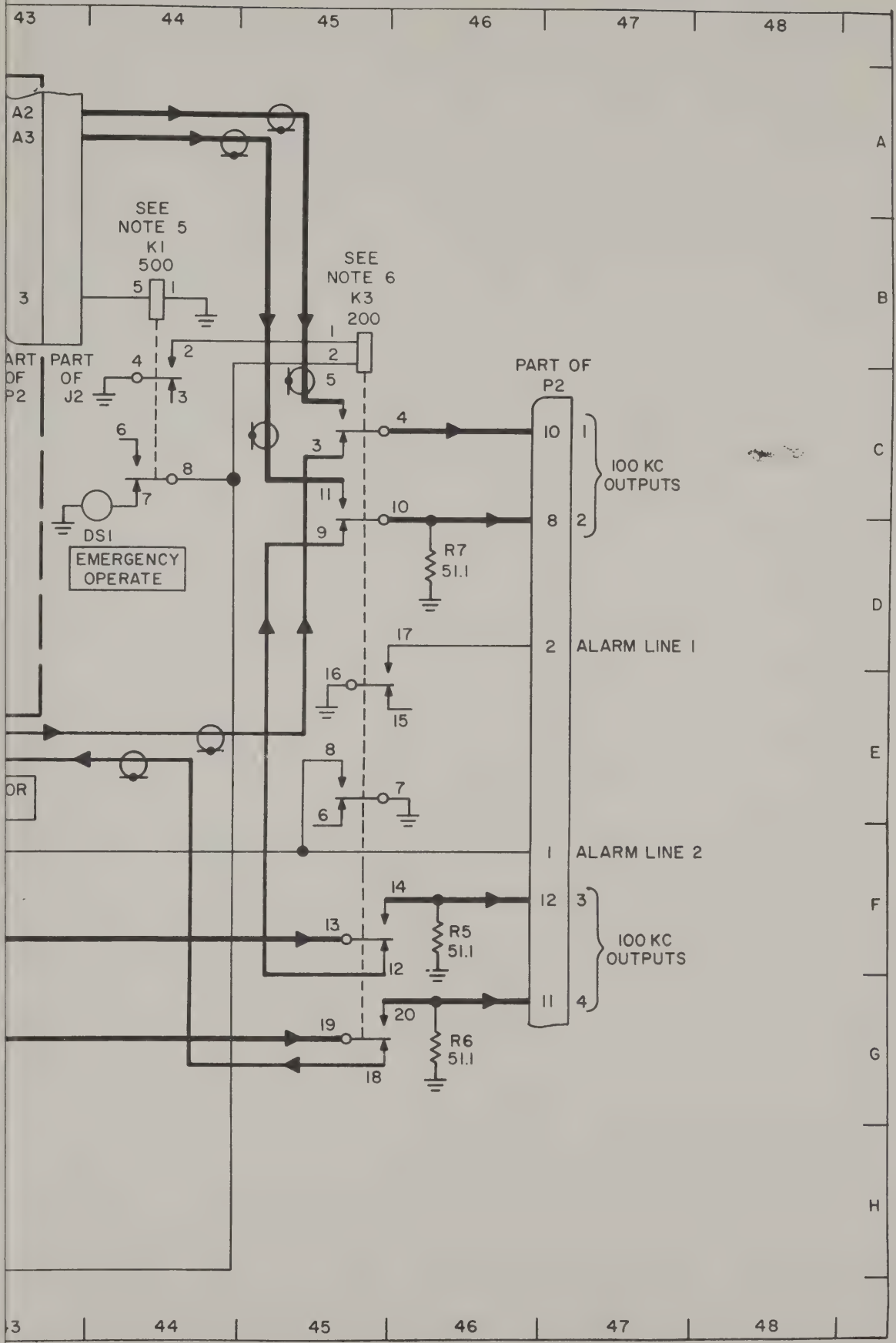
Figure 5-8. Signal Comparator CM-270/SRC-16, Schematic Diagram (Sheet 1 of 2)



ure 5-8. Signal Comparator CM-270/SRC-16, Schematic Diagram (Sheet 2 of 2)

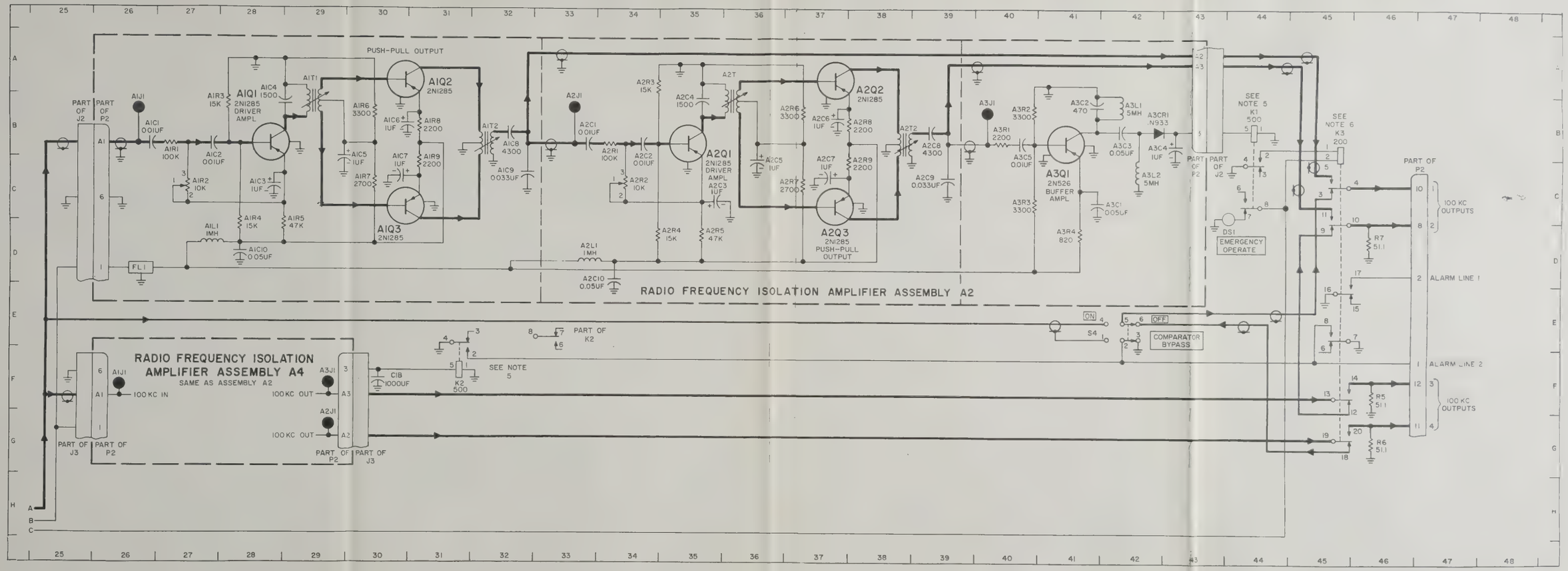


Figure 5-8. Signal Comparator CM-270/SRC-16, Schematic Diagram (Sheet 2 of 2)

SECTION 6

PARTS LIST

6-1. REFERENCE.

Refer to chapter O, volume 5

NAVSHIPS 0967-163-9040 (*Non-Registered*)

VOLUME 4

TECHNICAL MANUAL

for

RADIO SET AN/SRC-23(V)

CHAPTER N

RADIO TEST SET-MONITOR

TS-2476/SRC-23(V)

DEPARTMENT OF THE NAVY

NAVAL SHIP SYSTEMS COMMAND

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N2-1, N3-1	Original		

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SECTION 1

GENERAL INFORMATION

1-1. SCOPE.

This chapter describes Radio Test Set-Monitor TS-2476/SRC-23(V). The chapter contains general information, troubleshooting procedures, and maintenance procedures. Installation procedures are contained in chapter A, section 2 (volume 1). Operating procedures are contained in chapter A, section 3 (volume 2). Parts list information is contained in chapter O (volume 5).

. This chapter is in effect upon receipt. Extracts may be made from this chapter to facilitate preparation of other Department of Defense Publications.

1-2. ASSOCIATED MANUALS.

Troubleshooting and adjustment procedures for amplifier-mixer assembly A1, audio-frequency amplifier assembly A2, electronic control amplifier assembly A3, low-voltage power supply assembly A4, and high-voltage power supply assembly A5 are provided in the Technical Manual for Electronic Circuit Plug-in Unit Test Set AN/URM-158. The Maintenance Standards Book for Radio Set AN/SRC-23(V), NavShips 0967-163-9070 contains preventive maintenance schedules and procedures.

1-3. GENERAL DESCRIPTION.

Radio Test Set-Monitor TS-2476/SRC-23(V) (radio test set-monitor) (figure 1-1) is used to analyze the audio-frequency distortion of Radio Set AN/SRC-23(V). The radio test set-monitor is also used to perform system level checks, frequency-lock tests, and fsk performance tests. During the tests, the radio set is placed in its normal mode of operation. To measure distortion, the radio test set-monitor provides a two-tone audio signal which is transmitted around a closed loop and returned to the distortion analyzer circuits. To perform system level checks, the radio test set-monitor provides either of the two tones separately. The single tone is transmitted around the closed loop on the LSB, USB, or both sidebands and is monitored by the associated metering circuits of AF-RF Monitor ID-1370/SRC-23(V). During frequency-lock tests, one of the two tones is transmitted on both the LSB and USB sidebands of a selected channel. The received USB and LSB test tones are applied to opposite oscilloscope deflection plates. When the transmitter and receiver are properly locked to the same frequency, the resultant oscilloscope pattern is a nearly stable one-to-one Lissajous figure. To test fsk performance, the fsk audio tones are filtered from the USB channel and applied to the horizontal and vertical deflection plates of the oscilloscope. The vertical input is passed through a phase-shift network so that a characteristic X-pattern is displayed. When the fsk tones are equally displaced from the 2550-cps center frequency, the X-pattern is symmetrical.

The radio test set-monitor includes amplifier-mixer assembly A1, audio-frequency amplifier assembly A2, electronic control amplifier assembly A3, low-voltage power supply assembly A4, high-voltage power supply assembly A5, and chassis assembly A6. The radio test set-monitor is contained in a single unit which is suitable for rack mounting. Cables at the rear of the unit provide power and signal inputs and signal outputs from the chassis. The front panel of the unit contains power circuit breakers, selector switches, level controls, a cathode ray oscilloscope, and a VU meter for control and readout of signals within the unit.

1-4. REFERENCE DATA.

Frequency range	
Output	1275 and 1550 cps.
Input	300 to 3050 cps.
Output level	
Distortion mode	2.0 ±0.2 volts pev (peak envelope voltage) per tone of two-tone signal.
Level check mode	3.0 ±0.5 volts pev of single-tone signal.
Distortion output signal	Harmonics, intermodulation products, hum, and noise at least 70 db below a single tone of 0.775 volt pev, or a two-tone output of 0.55-volt pev per tone.
Input signal selectivity	Capable of measuring hum and distortion 70 db below a two-tone output of 0.55 volt per tone.
Power requirements	115 volts ac ±10 percent, single phase, 400 cps ±5 percent.
Power consumption	62 volts maximum (operating).

Impedance

Outputs at 1000 to 200 cps . . . . 600 ohms ±20 percent balanced.

Inputs at 300 to 3050 . . . 600 ohms ±20 percent balanced

Weight . . . . . 86 pounds.

Dimensions

Height . . . . 8-43/64 inches.

Width . . . . 18-57/64 inches.

Depth . . . . 27-13/32 inches.

1-5. EQUIPMENT SIMILARITIES.

There are no similarities between the radio test set-monitor and other existing equipment.

SECTION 2

INSTALLATION

2-1. REFERENCE.

Installation data for Radio Test Set-Monitor TS-2476/SRC-23(V) is provided in chapter A, section 2.

SECTION 3

OPERATION

3-1. REFERENCE.

Complete operating procedures for Radio Test Set-Monitor TS-2476/SRC-23(V) are described in chapter A, section 3. This section, covering system operating instructions for Radio Set AN/SRC-23(V), is printed separately as volume 2 of the technical manual.

SECTION 4

TROUBLESHOOTING

4-1. LOGICAL TROUBLESHOOTING.

The radio test set-monitor can be used to perform AN/SRC-23(V) system level checks, distortion tests, frequency-lock tests, and fsk performance tests. The input and output requirements of the radio test set-monitor are critical when the unit is operated to analyze distortion of Radio Set AN/SRC-23(V). Because of this, the radio test set-monitor self-test procedure of paragraph 3-66, chapter A, section 3 (volume 2) is provided to check the performance of the unit as a distortion analyzer before performing distortion tests on Radio Set AN/SRC-23(V). Also, the self-test procedure serves as a troubleshooting aid for the radio test set-monitor. Almost all of the radio test set-monitor circuits can be checked during the self-test operation. Furthermore, by manipulating the front panel TONE SELECT, FUNCTION, and FILTER SELECT switches, maintenance personnel with a thorough understanding of the functional operation of the equipment can make sound logical decisions as to the cause of malfunction or performance deterioration. Figure 4-1 is a servicing block diagram provided for module and circuit testing.

Troubleshooting for this equipment should be based on the six steps of logical troubleshooting. These six steps are as follows:

a. SYMPTOM RECOGNITION. - This is the first step in the troubleshooting procedure. All equipment troubles are not the direct result of component failure. Therefore, a trouble in an equipment is not always easy to recognize, since all conditions of less than peak performance are not always apparent. This type of equipment trouble is usually discovered while accomplishing preventive maintenance procedures, such as the POMSEE checks. It is important that the not so apparent troubles, as well as the apparent troubles, be recognized.

b. SYMPTOM ELABORATION. - After an equipment trouble has been recognized, all the available aids designed into the equipment should be used to further elaborate the original trouble symptom. Use of equipment front panel controls and other built-in indicating or testing aids should provide a better identification of the original trouble symptom. Also, checking or otherwise manipulating the operating controls may eliminate the trouble.

c. LISTING PROBABLE FAULTY FUNCTION. - The next logical step in troubleshooting is to formulate a number of educated guesses as to the cause and likely location (functional section) of the trouble. The educated guesses are mental decisions which are based on knowledge of the equipment operation, a full identification of the trouble symptom, and information supplied by the technical manual. The overall equipment functional discussion and block diagram should be referred to when selecting possible faulty functional sections.

d. LOCALIZING THE FAULTY FUNCTION. - For the greatest efficiency in localizing trouble, the functional sections which have been selected by the educated-guess method should be tested in the order that will require the least amount of time to find the faulty section. This requires a mental selection to determine which section to test first, i.e., quick sensory checks to eliminate possible trouble. The selection should be based on two factors: the validity of the educated guesses and the difficulties in making the necessary tests to check the functional section. Normal voltage indications are included at significant test points on the servicing block diagram, figure 4-1, to serve as aids in isolating the faulty section. Also, the test data supplied to augment the functional description and servicing block diagram of a functional section provides such information as pertinent control settings, critical adjustments, test equipment lists, and other necessary information which will aid in testing the functional section.

e. LOCALIZING TROUBLE TO CIRCUIT. - Once the cause of trouble has been isolated to amplifier-mixer assembly A1, audio-frequency amplifier assembly A2, electronic amplifier assembly A3, power supply assembly A4, or high-voltage power supply assembly A5, refer to module troubleshooting procedures described in the Technical Manual for Electronic Circuit Plug-in Unit Test Set AN/URM-158.

f. FAILURE ANALYSIS. - After the trouble has been located and corrected, review the steps taken and decide why the trouble affected the equipment in the manner it did. This step is taken to determine if other circuit elements were responsible for the malfunction.

4-2. OVERALL FUNCTIONAL DESCRIPTION.

Radio Test Set-Monitor TS-2476/SRC-23(V) is used to perform distortion tests, system level checks, frequency-lock tests, and fsk performance tests on Radio Set AN/SRC-23(V). The unit provides a two-tone audio output to measure audio distortion of the USB and LSB transmit and receive circuits. Either tone is applied to either the USB or LSB transmit circuits to perform system level measurements. Either tone is applied to both USB and LSB transmit circuits to perform the frequency-lock test. During each of these tests, the radio set is placed in its normal mode of operation, and the radio test set-monitor output is transmitted around a closed loop provided by the transmitter and receiver circuits. The output tone or tones are returned to the radio test set-monitor as received audio. When the FSK function is selected, fsk audio signals are received at the USB input to the radio test set-monitor and fed to the horizontal and vertical deflection circuitry of the radio test set-monitor oscilloscope through a dual bandpass filter.

4-3. FUNCTION SWITCH.

a. DESCRIPTION. - The FUNCTION switch selects tone F1, tone F2, or both tones for application to the USB, LSB, or both sidebands to perform distortion tests, system level checks, or frequency-lock tests. The FUNCTION switch sections are shown simplified on the block diagram, figure 4-1. Complete circuit details are shown on the Radio Test Set-Monitor TS-2476/SRC-23(V) schematic diagram, figure 5-15.

On the SELF TEST and DISTORTION USB or LSB positions, FUNCTION switch section S1H connects the F1 and F2 outputs from amplifier-mixer assembly A1 to XMIT TONE ATTENUATORS AT13 and AT12. On SELF TEST, the tones are applied through switch section S1E to high-fidelity transformer T1 at the input to the audio-frequency filter section. On DISTORTION USB or LSB, the tones are applied through switch section S1E to balanced USB or LSB audio output lines. The tones are then transmitted on a closed loop. Received USB or LSB two-tone audio from the closed loop is applied through switch sections S1A or S1B to high-fidelity transformer T1; the sideband opposite to that selected is terminated in 600 ohms.

On all LEVEL CHECK positions, FUNCTION switch section S1H connects the F1 and F2 outputs to TONE SELECT switch S2A. Only one tone is used to perform system level checks. Depending upon the TONE SELECT switch position, F1 or F2 is applied to XMIT TONE ATTENUATORS AT13 and AT12. Switch section S1E connects the attenuator AT12 output to impedance-matching transformer A2T1, which is mounted in the audio-frequency amplifier assembly. Switch sections S1D and S1E are each connected across one of the two secondary windings of A2T1 so that when LEVEL CHECK USB is selected, the tone is applied to the USB pair, and the LSB pair is terminated in 600 ohms. When the FUNCTION switch is positioned to BOTH, the single tone is applied to both sidebands. On the BOTH position, switch sections S1A and S1B apply the tone from both sidebands of the closed loop to the deflection plates of the radio test set-monitor oscilloscope, so that frequency-lock tests can be made.

On the FSK position, switch section S1B applies fsk audio signals received at the USB input to the HORIZ GAIN control R29. The LSB input is not used for fsk testing. When the FUNCTION switch is on FSK, dual bandpass filter FL9 is inserted in the signal path by switch section S1F. Switch sections S1F and S1G insert a phase-shift network between the output of impedance-matching transformer A3T2 and the input of the vertical deflection amplifier A3V1A.

b. TEST DATA.

(1) TEST EQUIPMENT REQUIRED.

(a) Multimeter CAQI-401C.

(2) REFERENCE ILLUSTRATIONS.

(a) Servicing block diagram, figure 4-1.

(b) Radio test set-monitor schematic diagram, figure 5-15.

(3) PROCEDURE. - The FUNCTION switch circuits are tested by resistance measurements and continuity checks. Refer to table 4-1 for test data.

4-4. TONE GENERATING CIRCUITS.

a. FUNCTIONAL DESCRIPTION. - The radio test set-monitor tone generating circuits consist of tuning fork oscillators Y1 and Y2 and amplifier-mixer assembly A1 (figure 4-1). The purpose of the tone generating circuits is to provide the fundamental frequencies, F1 and F2, of the two audio output tones. The tones can be mixed to provide the two-tone audio signal used to analyze distortion, or either tone can be generated singly to perform system level checks and frequency-lock tests. All harmonics, intermodulation products, hum, and noise are suppressed at least 70 db below a single-tone output of 0.775-volt pev (peak envelope voltage) or a two-tone output of 0.55-volt pev.

(1) TUNING FORK OSCILLATORS. - Tuning fork oscillator Y1 generates the F1 fundamental frequency of 1275 cps, and tuning fork oscillator Y2 generates the F2 fundamental frequency of 1550 cps. The B+ supply to the transistors within each tuning fork oscillator is controlled by TONE SELECT switch S2, so that the associated oscillator is energized when the switch is turned to F1 or F2. When energized, each tuning fork oscillator delivers a minimum 3-volt rms signal to the associated F1 or F2 TONE LEVEL control, R1 or R2. The F1 and F2 TONE LEVEL controls, located on the front panel, are used to adjust the input signal levels of the F1 and F2 tones applied to amplifier-mixer assembly A1.

(2) AMPLIFIER-MIXER ASSEMBLY A1. - Amplifier-mixer assembly A1 contains two identical 3-stage audio amplifiers, F1 and F2 bandpass filters A1FL1 and A1FL2, and a mixing pad. The audio amplifiers are mounted on separate boards as subassemblies A1A1 and A1A2 within amplifier-mixer assembly A1. Because the audio amplifiers are identical, only the F1 amplifier circuitry mounted on subassembly A1A1 requires description. The 1275-cps F1 tone from tuning fork oscillator Y1 is coupled through capacitor A1A1C1 to F1 TONE LEVEL CONTROL R1 on the front panel. The F1 TONE LEVEL control adjusts the input signal level applied to matching transformer A1A1T1. Test jacks A1A1J1 and A1A1J2 are provided to meter the signal level at the primary and secondary of the matching transformer. Signal is applied to the base of common emitter amplifier A1A1Q1. The common emitter stage has high current gain and low input impedance. It has low distortion because of the large amount of negative feedback in the circuit. Grounded-collector amplifier A1A1Q2 functions as an impedance-matching stage between the high output impedance of A1A1Q1 and the low input impedance of A1A1Q3. Common emitter amplifier A1A1Q3 provides additional amplification of the 1275-cps F1 tone with low distortion. Negative feedback is provided between common emitter amplifiers A1A1Q3

TABLE 4-1. FUNCTION SWITCH TEST DATA

FUNCTION SWITCH POSITION	POINT OF MEASUREMENT	RESISTANCE (ohms)
SELF TEST	AT12-OUT to ground	9
SELF TEST	AT12-C to ground	9
DISTORTION LSB	P1-3 and 4	600 ±20%
DISTORTION LSB	P1-1 and 2	∞
DISTORTION LSB	P1-10 and 11	18
DISTORTION USB	P1-1 and 2	600 ±20%
DISTORTION USB	P1-3 and 4	∞
DISTORTION USB	P1-5 and 6	18
LEVEL CHECK USB	P1-1 and 2	60 ±20%
LEVEL CHECK USB	P1-3 and 4	∞
LEVEL CHECK BOTH	P1-5 and 8	0
LEVEL CHECK BOTH	P1-6 and 9	0
LEVEL CHECK BOTH	P1-10 and 12	0
LEVEL CHECK BOTH	P1-11 and 13	0
LEVEL CHECK LSB	P1-3 and 4	60 ±20%
LFVEL CHECK LSB	P1-1 and 2	∞

and A1A1Q1 to improve the overall linearity of the amplifier. Current feedback is applied from the emitter of A1A1Q3 to the base of A1A1Q1 through resistor A1A1R9. Voltage feedback is applied from the collector of A1A1Q3 to the emitter of A1A1Q1 through resistor A1A1R11 and capacitor A1A1C6.

The F1 and F2 outputs of the two identical 3-stage amplifiers are applied to step-up voltage transformers A1A3T1 and A1A3T2. Test jacks A1A1J4 and A1A2J4 are provided at the transformer secondaries for test purposes. Bandpass filters A1A3FL1 and A1A3FL2 consist of LC networks which pass the 1275-cps F1 and the 1550-cps F2 tones. Undesired harmonics of each tone are attenuated at least 70 db below the level of the tone by the associated bandpass filter. When FUNCTION switch S1 is placed on the SELF TEST or DISTORTION LSB or USB positions to perform distortion tests, the F1 and F2 output tones are applied through a mixing pad to the XMIT TONE ATTENUATORS. The complete mixing pad circuit is shown schematically in figure 5-14. Identical T-networks consisting of resistors R15, R16, and R17 are mounted on subassemblies A1A1 and A1A2. The mixing pad accomplishes two purposes. It presents a nominal 600-ohm impedance to the balanced audio output line, and it serves to isolate the F1 and F2 outputs in order to reduce intermodulation products. When the FUNCTION switch is positioned to any LEVEL CHECK position, the mixing pad is not used, and a lower signal level is required. Some of the mixing pad components, resistors A1A1R15 and A1A1R16 and resistors A1A2R15 and A1A2R16, function as voltage dividers at the F1 and F2 outputs.

b. TEST DATA.

(1) TEST EQUIPMENT REQUIRED.

(a) Multimeter CAQI-410C.

(b) Electronic Voltmeter ME-30A/U.

(2) REFERENCE ILLUSTRATIONS.

(a) Servicing block diagram, figure 4-1.

(b) Test-point and assembly locations, figure 5-1.

(c) Radio test set-monitor schematic diagram, figure 5-15.

(d) Parts location illustrations, figures 5-1 through 5-7 and figures 5-11 and 5-12.

(3) PROCEDURES. - Several logical checks can be made to localize trouble within the tone generating circuits functional section. Perform the output level checks using single tones F1 and F2 separately. Check the output levels with the FUNCTION switch set to the following four positions: DISTORTION USB, DISTORTION LSB, LEVEL CHECK USB, and LEVEL CHECK LSB. Refer to the servicing block diagram, and analyze the trouble symptoms as follows:

(a) If normal output levels are obtained when the FUNCTION switch is on either DISTORTION position, but not when the FUNCTION switch is on either LEVEL CHECK position, the trouble is in either the FUNCTION switch circuits, impedance-matching transformer A2T1, or TONE SELECT switch sections S2A.

(b) If all output levels are normal for one single tone, but the other tone output level is abnormal, the trouble is in the tune fork oscillator or amplifier-mixer circuits associated with the abnormal tone. Measure the voltages at the test jacks associated with the faulty tone circuit to isolate the trouble to either the tune fork oscillator or to a stage within amplifier-mixer assembly A1.

(c) If low or otherwise abnormal output levels are indicated for both the F1 and F2 tones, the trouble is either in the power supply or the B+ switching circuits to the amplifier-mixer assembly.

(4) TEST-POINT VOLTAGES. - Normal test-point voltages measured at amplifier-mixer assembly A1 test jacks are indicated on the servicing block diagram.

Note

The signal voltages are based on an input signal of 25 millivolts rms, as indicated at test jacks A1A1J1 or A1A2J1.

4-5. DISTORTION ANALYZER CIRCUITS.

a. FUNCTIONAL DESCRIPTION. - The distortion analyzer circuits consist of high-fidelity transformer T1, audio-frequency filter section, LEVEL MEASUREMENT attenuators AT10 and AT11, audio-frequency amplifier assembly A2, and the front panel VU meter. The distortion analyzer circuits are capable of measuring hum and distortion 70 db below a two-tone input of 0.707-volt pev (peak envelope voltage). Refer to the block diagram, figure 4-1.

(1) AUDIO FREQUENCY FILTER SECTION. - During distortion tests, two-tone audio is applied to the audio-frequency filter section through high-fidelity transformer T1. The high-fidelity transformer passes audio tones with negligible distortion. FILTER SELECT switch S3 applies the two-tone audio to one of eight bandpass filters. Each bandpass filter passes a particular component of the received two-tone audio signal. Resistive attenuator pads associated with each filter are factory-adjusted to compensate for individual differences in filter inserting loss. Input and output impedances remain unchanged. Harmonics and intermodulation products of the received two-tone audio signal other than those sampled by the filters do not fall within the 300 to 3050-cps bandwidths of the LSB and USB channels.

(2) LEVEL MEASUREMENT ATTENUATORS. - LEVEL MEASUREMENT attenuators AT10 and AT11 provide a step attenuator network in the received two-tone audio signal path. AT10 provides 0 to 40 db of attenuation in 10-db steps. Attenuator AT11 provides 0 to 10 db attenuation in 1-db steps. During the distortion test, the LEVEL MEASUREMENT attenuators are first set for maximum attenuation (50 db, 0 positions) while a single reference tone (F1 or F2) is applied to the VU meter. Next, the single-tone level is adjusted with the RECEIVE AUDIO LEVEL control to obtain a 0-VU reference indication on the VU meter. The selected components of the two-tone audio signal are applied to the VU meter, and attenuation is gradually removed from the receive signal path until the 0-VU reference level is obtained, or until total attenuation can be determined from the VU meter indication and the LEVEL MEASUREMENT attenuator controls. Algebraic subtraction of the VU meter indication from the attenuation indicated by the LEVEL MEASUREMENT controls provides the total attenuation of a particular component below the level of the reference tone.

Note

The LEVEL MEASUREMENT attenuators are set for maximum attenuation in the 0-db positions.

(3) AUDIO FREQUENCY AMPLIFIER ASSEMBLY A2. - Audio-frequency amplifier assembly A2 amplifies the received audio frequencies to the levels required to drive the VU meter. The received audio signals are applied to emitter follower stage A2Q1 which is shunted by 600 ohms. The purpose of the emitter follower stage is to match the 600-ohm output impedance of LEVEL MEASUREMENT attenuator AT10. Common emitter amplifiers A2Q2 through A2Q4 function as a 3-stage, RC-coupled audio amplifier which provides between 43 and 75 db of audio gain. The three amplifier stages are similar except that the first stage is provided with additional power supply decoupling by resistor A2R6 and capacitor A2C4. Also, the bias on the base of A2Q2 is applied from the collector circuit through resistor A2R1. This decreases the effects of the power supply 400-cps and 800-cps ripple components.

The gain of the 3-stage audio amplifier is controlled by front panel RECEIVE AUDIO LEVEL potentiometers R23A and R23B. The potentiometers are part of the emitter circuits of A4Q3 and A4Q4, respectively.

When the RECEIVE AUDIO LEVEL control is turned fully clockwise, minimum resistance is inserted in the emitter circuits, and approximately 72 db of gain is obtained. When the RECEIVE AUDIO LEVEL control is turned fully counterclockwise, the gain is reduced to approximately 45 db. Amplified audio signal is coupled from the output of the third audio stage, A2Q4, to emitter follower A2Q5. The emitter follower matches the high output impedance of A2Q4 to the VU meter circuit. A meter protection circuit consisting of stabistors A2CR1 through A2CR6 protects the VU meter against signal voltages higher than 2 volts peak-to-peak. Test jacks A2J1, A2J2, and A2J3 are provided for test measurements of the input signal, the +28-volt bias (B+), and the output signal, respectively. Although transformer A2T1 is mounted in audio-frequency assembly A2, the transformer functions as part of the tone generating circuits described in paragraph 4-4.

(4) VU METER M1. - VU meter M1 functions with LEVEL MEASUREMENT attenuators AT10 and AT11 to indicate the level of a selected audio component of the received audio signal below the level of a single tone. The total vu level of the component is the algebraic subtraction of the VU meter reading from the LEVEL MEASUREMENT attenuator control settings. Usually, the 0- to 10-db attenuator is adjusted to obtain a 0-VU meter reading, and the total level below a single tone is represented by the LEVEL MEASUREMENT attenuator control setting. Levels more than 50 db below the level of a single tone are indicated on the VU meter. For example, if the LEVEL MEASUREMENT attenuator controls are set to 40 and 10, and the VU meter indicates -5 VU, the total level below that of a single tone is 55 db.

b. TEST DATA.

(1) TEST EQUIPMENT REQUIRED.

(a) Multimeter CAQI-410C.

(b) Electronic Voltmeter ME-30A/U.

(2) REFERENCE ILLUSTRATIONS.

(a) Servicing block diagram, figure 4-1.

(b) Radio test set-monitor schematic diagram, figure 5-15.

(c) Parts location illustrations, figures 5-1 through 5-4, 5-8, 5-9, 5-11 and 5-12.

(3) PROCEDURE. - Perform the following steps to localize trouble within the distortion analyzer circuits.

(a) Set up the radio test set-monitor for self-test operation as described in paragraph 3-6b, chapter A, section 3 (volume 2).

(b) Connect the electronic voltmeter between audio-frequency amplifier assembly input jack A2J1 (figure 5) and chassis ground.

(c) Set the FILTER SELECT switch to F1 and then to F2, and measure the signal input voltage. If the voltage is abnormally high or low on both positions, check LEVEL MEASUREMENT attenuators AT10 and AT11. If voltage is abnormally high or low on one position only, check the audio-frequency filter section and FILTER SELECT switch sections. Refer to filter attenuator adjustment procedures in paragraph 5-2. If input voltage is zero for both positions, check high-fidelity transformer T1. When input voltage to audio-frequency amplifier assembly A2 is normal, proceed to step d.

(d) Connect electronic voltmeter between audio-frequency amplifier output jack A2J3 (figure 5-8) and chassis ground. Output voltage for F1 and F2 single tones should be approximately +4 dbm (1.228 volts rms).

(e) If normal output levels are not indicated, adjust RECEIVE AUDIO LEVEL control to obtain 1.228 volts rms. If normal output levels cannot be obtained by adjusting RECEIVE AUDIO LEVEL control, check B+ supply with multimeter at test jack A2J2 (figure 5-8). Make voltage measurements at transistor terminals to isolate trouble to a stage or component.

Note

Normal ac signal and dc bias voltages are indicated on the radio test set-monitor schematic diagram, figure 5-15.

(f) When the audio-frequency amplifier output voltage can be adjusted above 1.5 volts rms, check stabistors A2CR1 through A2CR6.

(g) If the audio-frequency amplifier output voltages measured at test jack A2J3 are normal, the trouble is in VU meter M1.

4-6. OSCILLOSCOPE SIGNAL CIRCUITS.

a. DESCRIPTION.

(1) SIGNAL PATH FOR FREQUENCY-LOCK TEST. - Refer to the servicing block diagram, figure 4-1. The level of the USB test tone is controlled by HORIZ GAIN control R29. The USB test tone is coupled to horizontal amplifier A3V1B through impedance-matching transformer A3T2. The horizontal amplifier output is impressed upon a negative dc bias which is applied to the horizontal deflection plate of the cathode ray tube, V1. The dc bias is controlled by HORIZ POS control R28 to adjust the horizontal position of the oscilloscope display. The level of the LSB test tone is controlled by VERT GAIN control R26. The LSB test tone is coupled to vertical amplifier A3V1A through impedance-matching transformer A3T1. The vertical amplifier output is impressed upon a negative dc bias which is applied to the vertical deflection plate of the crt. VERT POS control R25 controls dc bias to adjust the vertical position of the oscilloscope display. When USB and LSB test tones of equal amplitude and frequency are applied to the horizontal and vertical deflection plates, a stable one-to-one Lissajous figure is displayed on the oscilloscope. The pattern will be an ellipse, a circle, or a straight line, depending on the phase relationship between USB and LSB test tones. A slight

frequency difference will cause the pattern to rotate slowly. When the receiver and transmitter under test are locked on the same operating frequency, the USB and LSB test tones are identical, and the pattern does not rotate.

(2) SIGNAL PATH FOR FSK RECEIVE TEST. - (Refer to the servicing block diagram, figure 4-1. Fsk audio signals are received at the USB input to the radio test set-monitor. The LSB input is not used for the fsk test. The 850-cps fsk mode of receiver operation produces audio tones -425 cps from a 2550-cps center frequency to represent teletypewriter mark and space pulses. Thus, space tones of 2125 cps and mark tones of 2975 cps are received in alternating sequence. The fsk audio input level is adjusted by HORIZ GAIN control R29. When the FUNCTION switch is on FSK, dual bandpass filter FL9 is inserted in the signal path. The purpose of the dual bandpass filter is to pass the 2125- and 2975-cps fsk audio tones and to reject all other signals present at the USB input. The fsk audio tones are coupled through impedance-matching transformer A3T2 to the input of horizontal amplifier A3V1B. Fsk audio tones are also applied to the input of vertical amplifier A3V1A through a crossover phase-shift network.

The components of the phase-shift network, A3C5 and A3L1, are designed to produce a 90-degree phase shift at 2550 cps. Therefore, a space tone of 2125 cps is phase shifted less than 90 degrees, and a mark tone of 2975 cps is shifted more than 90 degrees. When a 2125-cps space tone is applied to the horizontal and vertical deflection plates, a negatively sloped slanting line or ellipse is displayed on the oscilloscope. When a 2975-cps mark tone is applied to the deflection plates, a positively sloped slanting line or ellipse is displayed. The two patterns are displayed in rapid succession to form a double pattern. Under ideal conditions, the fsk audio tones will be equally displaced -425 cps from the 2550-cps center frequency. Hence, the crossover network will phase shift both the 2125-cps space tone and the 2975-cps mark tone the same amount either side of 90 degrees. Under these conditions, the oscilloscope patterns are symmetrical. If the fsk tones are not displaced -425 cps on each side of the 2550-cps center frequency, the phase shift of the tone nearer the center frequency will approach 90 degrees, and a more nearly circular pattern will be displayed. The tone whose frequency is the farther from center will be phase shifted more nearly 180 degrees, and the oscilloscope pattern produced by this tone will approach a straight line. Under fsk test conditions, the receiver BFO is adjusted to produce tones -425 cps from the 2550-cps center frequency. When this is accomplished, the oscilloscope will display symmetrical patterns.

b. TEST DATA.

(1) TEST EQUIPMENT REQUIRED.

(a) Signal Generator CAQI-606A.

(b) Multimeter CAQI-410C.

(2) REFERENCE ILLUSTRATIONS.

(a) Servicing block diagram, figure 4-1.

(b) Parts location illustrations, figures 5-1 through 5-4.

4-7. POWER SUPPLY.

a. FUNCTIONAL DESCRIPTION. - The radio test set-monitor operates on 115-volt ac, 400-cps, single-phase primary power. When POWER ON-OFF circuit breaker CB1 is set to ON, primary power is applied to low-voltage power supply assembly A4 and high-voltage power supply assembly A5 (figure 4-1). The circuit breaker protects the primary power source against current overloads in excess of 0.5 ampere. In case of overload, the POWER ON-OFF toggle switch is tripped to OFF and must be reset to ON after the cause of overload is corrected.

(1) LOW-VOLTAGE POWER SUPPLY ASSEMBLY A4. - The low-voltage power supply assembly provides +28 volts dc to tuning fork oscillators Y1 and Y2, amplifier-mixer assembly A1, and audio-frequency assembly A2. The 115-volt primary power is applied across stepdown transformer A4T1 to rectifier diodes A4CR1 and A4CR2. The resultant dc voltage is filtered by resistors A4R2 and A4R1 and capacitor A5C1. Zener diode A4CR3 provides a 28-volt (±1-volt) dc reference. The 28-volt supply is switched to one or both tuning fork oscillators by TONE SELECT switch S2. B+ is supplied continuously to amplifier-mixer assembly A1 and audio-frequency amplifier assembly A2. Choke coil A4L1 and capacitor A4C2 provide additional filtering to reduce the 400-cps ripple and 800-cps ripple harmonic on the B+ line to the low-level amplifier stages in audio-frequency amplifier assembly A2. Test jacks A4J3 and A4J4 are provided for test measurements of the B+ voltages applied to the assemblies. Test jacks A4J1 and A4J2 are provided for ac input voltage measurements across the primary transformer A4T1.

(2) HIGH-VOLTAGE POWER SUPPLY ASSEMBLY A5. - The high-voltage power supply provides (1) +200 volts dc for dual triode amplifier tube A3V1, (2) -800 volts dc for cathode ray tube V1, and (3) 6.3-volt ac filament voltage for both tubes. The +200-volt dc B+ voltage is developed by a single-phase, full-wave rectifier which drives a choke input filter. Test jack A5J1 is provided at the output for test measurements. Filament voltage is provided by a 6.3-volt secondary winding on power transformer A5T1. A single-phase full-wave rectifier with resistance-capacitance filter sections provides -800 volts dc to operate the cathode ray tube. Test jack A5J2 is provided at the output for test measurements. The -800 volts dc is applied directly to the control grid of the crt. Display intensity is controlled by INTENSITY control R27 which applies a slightly less negative voltage to the cathode. FOCUS control R24 provides a less negative voltage to the second anode to maintain electron beam focus.

b. TEST DATA.

(1) TEST EQUIPMENT REQUIRED.

(a) Multimeter CAQI-410C.

(b) Electronic Voltmeter, ME-30A/U.

(2) REFERENCE ILLUSTRATIONS.

(a) Servicing block diagram, figure 4-1.

(b) Radio test set-monitor schematic diagram, figure 5-15.

(c) Parts location illustrations, figures 5-10 through 5-14.

(3) PROCEDURE FOR POWER SUPPLY ASSEMBLY A4.

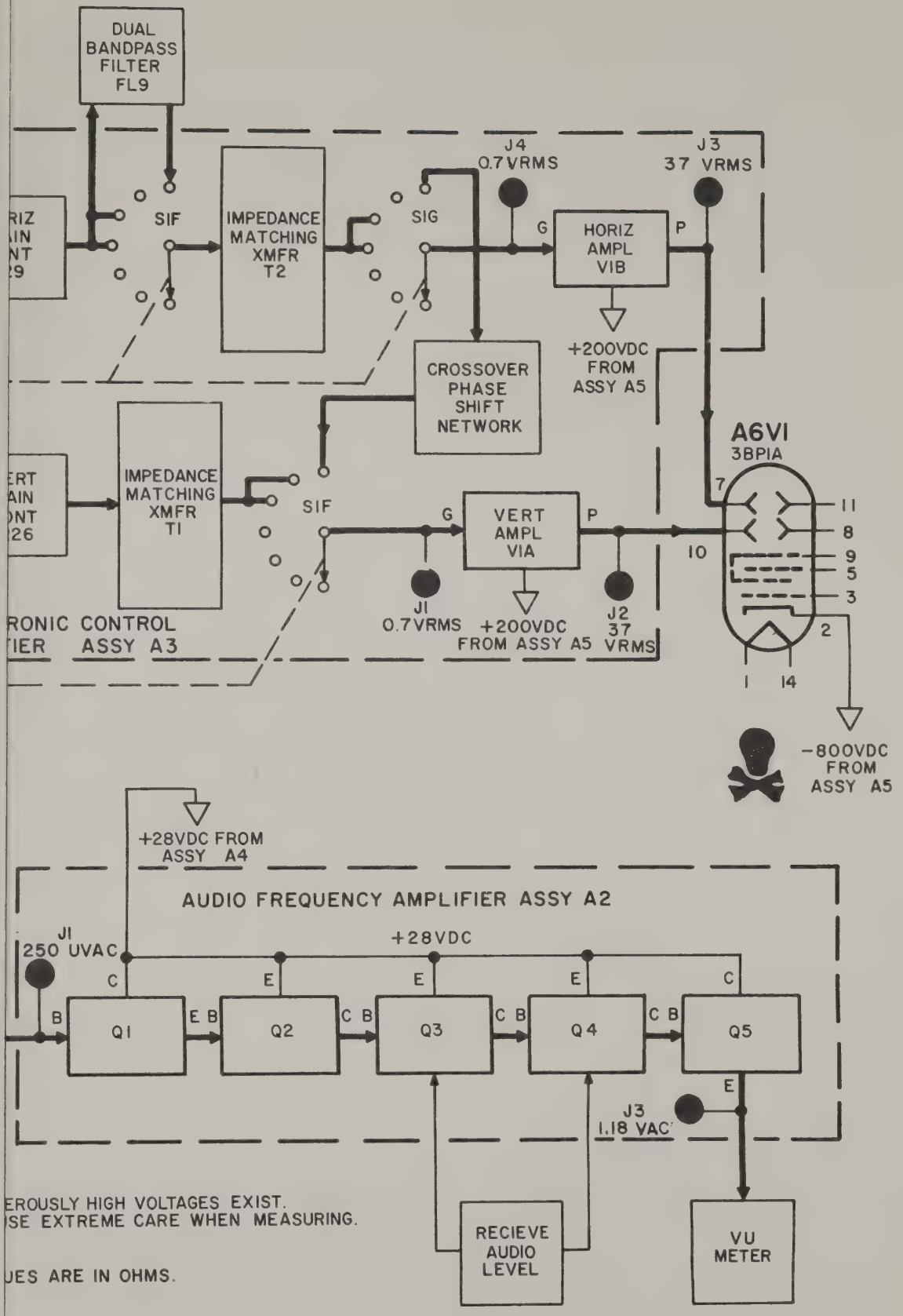
(a) Check +28 volts dc at power supply test jacks A4J3 and A4J4. If B+ voltage is present at A4J4 but not at the amplifier assemblies, the trouble is in the chassis wiring. If B+ voltage is present at test jack A4J3 but not at A4J4, the trouble is caused by choke coil A4L1 or capacitor A4C2.

(b) Check for the 115-volt ac input at test jacks A4J1 and A4J2 (across the primary of transformer A4T1). If voltage is present, trouble is in transformer, rectifier diodes, or filter circuit components. If ac voltage is not present, check circuit breaker CB1 and chassis wiring between power supply and connector P1 on rear of unit. Refer to schematic diagram, and make continuity checks.

(4) PROCEDURE FOR HIGH-VOLTAGE POWER SUPPLY ASSEMBLY A5.

(a) Check for +200 volts dc at J1 and -800 volts dc at A5J2. If neither voltage is present, check for 115 volts ac at A5T1 primary. If 115 volts ac is present at A5T1 primary, trouble is in transformer. If 115 volts ac is present at A5T1 primary, and only one dc voltage is present at A5J1 and A5J2, then the trouble is in the rectifier diodes or filter components of the inoperative power supply.

(b) If 115 volts ac is not present at A5T1 primary, check circuit breaker CB1 and chassis wiring between power supply and connector P1 at the rear of unit. Refer to schematic diagram, and make continuity checks.



re 4-1. Radio Test Set-Monitor TS-2476/SRC-23(V), Servicing Block Diagram

(c) Parts location illustrations, figures 5-10 through 5-14.

(3) PROCEDURE FOR POWER SUPPLY ASSEMBLY A4.

(a) Check +28 volts dc at power supply test jacks A4J3 and A4J4. If B+ voltage is present at A4J4 but not at the amplifier assemblies, the trouble is in the chassis wiring. If B+ voltage is present at test jack A4J3 but not at A4J4, the trouble is caused by choke coil A4L1 or capacitor A4C2.

(b) Check for the 115-volt ac input at test jacks A4J1 and A4J2 (across the primary of transformer A4T1). If voltage is present, trouble is in transformer, rectifier diodes, or filter circuit components. If ac voltage is not present, check circuit breaker CB1 and chassis wiring between power supply and connector P1 on rear of unit. Refer to schematic diagram, and make continuity checks.

(4) PROCEDURE FOR HIGH-VOLTAGE POWER SUPPLY ASSEMBLY A5.

(a) Check for +200 volts dc at J1 and -800 volts dc at A5J2. If neither voltage is present, check for 115 volts ac at A5T1 primary. If 115 volts ac is present at A5T1 primary, trouble is in transformer. If 115 volts ac is present at A5T1 primary, and only one dc voltage is present at A5J1 and A5J2, then the trouble is in the rectifier diodes or filter components of the inoperative power supply.

(b) If 115 volts ac is not present at A5T1 primary, check circuit breaker CB1 and chassis wiring between power supply and connector P1 at the rear of unit. Refer to schematic diagram, and make continuity checks.

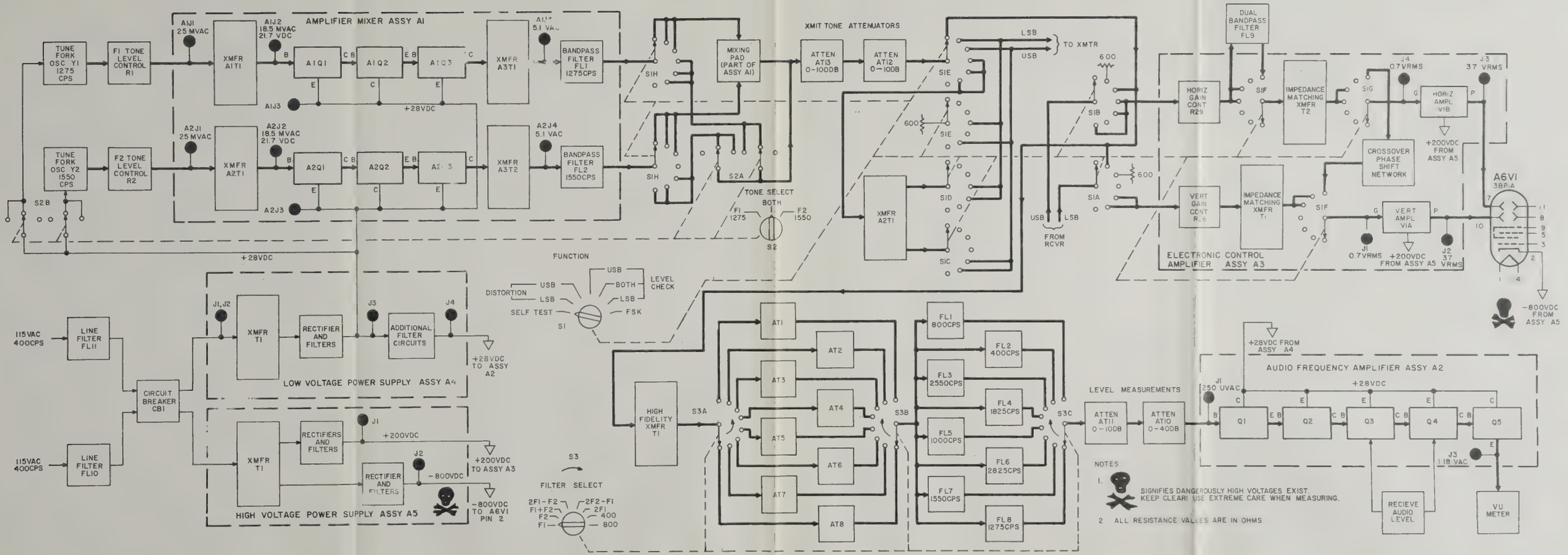


Figure 4-1. Radio Test Set-Monitor TS-2476/SRC-23(V), Servicing Block Diagram

SECTION 5

MAINTENANCE

5-1. PREVENTIVE MAINTENANCE.

Refer to the Maintenance Standards Book for Radio Set AN/SRC-23(V) for preventive maintenance schedules and procedures.

5-2. ALIGNMENT AND ADJUSTMENT.

All operational adjustments are accomplished by manipulating the front panel controls as described in chapter A, sections 3 through 6 and table 3-3 (volume 2). Internal adjustment of the radio test set-monitor is not required unless one of the bandpass filters in the audio-frequency filter section is replaced. The attenuation of each bandpass filter is compensated for by factory adjustment of the associated attenuator circuit. Before operating the radio test set-monitor with a new bandpass filter, compensate for the filter attenuation by readjusting the associated attenuator.

a. TEST EQUIPMENT REQUIRED. - The following test equipment items are required to perform the attenuator adjustments:

(1) Audio Oscillator TS-382A/U.

(2) Electronic Voltmeter ME-30A/U.

(3) Digital Electronic Counter CP-843(P)/U, with Time Interval Unit TD-785/U.

b. PROCEDURE.

(1) Set CIRCUIT BREAKER CB1 to ON position.

(2) Set LEVEL MEASUREMENT attenuator controls fully clockwise to 10 and 40 positions (0 attenuation).

(3) Set FILTER SELECT switch to F1 position.

(4) Set FUNCTION SELECT switch to DISTORTION USB.

(5) Loosen the four chassis-holding screws located at the four corners of the front panel. Press the two chassis-release buttons located at the two upper corners of the front panel, and pull the chassis out to its extended position.

(6) Connect the audio oscillator and counter between S3A-12 (the long clip of FILTER switch section S3A, figure 5-4) and the chassis.

(7) Connect the vtvm between the audio-frequency amplifier assembly test jack A2J1 (figure 5-1) and the chassis.

(8) Remove the replaced bandpass filter, and connect jumper wire across pins 5 and 8 of octal filter socket (figure 5-2).

(9) Adjust audio oscillator to bandpass filter frequency indicated in table 5-1.

(10) Set FILTER switch to position corresponding to bandpass filter.

(11) Loosen the locking bushing, and adjust attenuator to maximum clockwise position.

(12) Adjust audio oscillator output level to obtain the vtvm reading at test jack A2J1 as indicated in table 5-1. Record vtvm indication in db.

Note

Do not change control settings of audio oscillator or vtvm.

(13) Remove jumper wire from pins 5 and 8 of octal socket, and insert replacement filter.

(14) Adjust attenuator to obtain a vtvm indication at test jack A2J1 which is either 7 or 8 db below reading in step 13 (see table 5-1 for proper level).

(15) Tighten the locking bushing on the adjusted attenuator, remove the test equipment connections, and replace the radio test set-monitor in rack.

5-3. REMOVAL AND REPLACEMENT OF UNIT, ASSEMBLIES, AND PARTS.

a. UNIT REMOVAL AND REPLACEMENT. - To extend the unit, loosen the four chassis-holding screws located at the four corners of the front panel, press the two chassis-release buttons located at the two upper corners of the front panel, and pull the chassis out to its extended position. To remove the unit from its side rails, extend the unit, unplug the chassis-to-cabinet cable at the rear of the chassis, loosen the side rail setscrews, push the unit forward a few inches, and lift the unit clear of the side rails. Replace the unit by following the opposite of the above removal procedure.

b. ASSEMBLIES. - The power supply, amplifier-mixer, and audio-frequency amplifier assemblies are shown in figure 5-1. Each assembly is removed by loosening the four Phillips-head screws located on the corners of the assembly. These screws are recessed and painted red for easy identification. After loosening the screws, remove the assembly by lifting on the finger ring at the top of the assembly.

c. AUDIO-FREQUENCY FILTER SECTION. - The bandpass filters are plug-in items which mount in octal base tube sockets. The eight bandpass filters are secured to the chassis by a mounting bracket. Remove the bracket by loosening the eight retaining screws which secure it to the chassis.

d. TUNING FORK OSCILLATORS. - Tuning fork oscillators Y1 and Y2 are shown in figure 5-2. Each oscillator is secured to the chassis with four nuts located on the underside of the chassis. Before removing an oscillator, put identification tags on the wires connected to the terminals. Then unsolder the wires and remove the nuts.

TABLE 5-1. ATTENUATOR ADJUSTMENT DATA

FILTER	ATTENUATOR	ADJUST AUDIO OSCILLATOR		REQUIRED OUTPUT LEVEL
		FREQ (cps)	LEVEL	
FL8	AT8	1275	1.0 volt rms	-7 db
FL7	AT7	1550	1.0 volt rms	-7 db
FL6	AT6	2825	10.0 millivolts	-8 db
FL5	AT5	1000	10.0 millivolts	-8 db
FL4	AT4	1825	10.0 millivolts	-8 db
FL3	AT3	2550	10.0 millivolts	-8 db
FL2	AT2	400	10.0 millivolts	-8 db
FL1	AT1	800	10.0 millivolts	-8 db

e. REMOVAL OF CATHODE RAY TUBE AGV1.

(1) Remove the four screws which fasten the oscilloscope face plate to the front panel.

(2) Loosen the metal strap which holds the base of the oscilloscope in place.

(3) Disconnect the cathode ray tube from the tube socket, and remove it from the chassis by pulling it through the opening in the front panel.

f. PRINTED CIRCUIT BOARD REPAIR. - Parts mounted on the printed circuit boards are bonded to the boards to protect them from damage from humidity and moisture. This bonding (postcoating) also serves to protect the parts against excessive vibration in service. If the repair process requires that a part be removed from the board and replaced with another part, the following procedure should be followed. The bonding agent to be used in recoating the boards is a postcoating material, Dennis 1169 (Federal Stock Number 5970-738-5960). This material consists of two parts, Dennis 1169A and 1169B, which must be mixed.

(1) Inspect the board of evidence of burns, scorches, heat damage, corroded metal parts or terminals, or delamination of the base laminate. If any of these defects are evident, replace the entire board rather than attempting repair. If the board appears repairable, proceed to step 2.

(2) Remove the designated part from the printed board by destroying the protective postcoating with a hot soldering iron; then unsolder the part, and lift it off the board with a pair of long-nosed pliers.

CAUTION

Do not use soldering irons rated above 100 watts on boards bearing transistors, Cerafil capacitors, or other heat sensitive components. Also, exercise care when removing components from printed circuit boards so that the circuitry is not damaged.

(3) If necessary, remove the excess solder from the joint with a soldering iron.

(4) Insert the new wire or component lead in the correct tubelet, and clinch the wire over the tubelet.

(5) Apply solder to the joint using any rosin flux core solder conforming to QQ-S-571 type AR or 63/37 (tin-lead) solid wire solder and rosin flux. Do not use a solder that has a core of hydrazine, acid, or other unapproved flux. Do not keep the iron on the joint longer than necessary to complete the solder flow throughout the joint.

(6) Inspect the solder joint to be sure the solder completely covers metal surfaces, component leads, tubelets, eyelets, or terminals which have been soldered and that there is a smooth continuous fillet of solder between tubelet flares and the circuitry. Also note that there are no cold or fractured solder joints or nonadherence of solder to metal and no excess solder globules, peaks, strings, or bridges of solder between adjacent parts or circuits.

(7) Clean the joint to remove the flux, using a medium-bristled brush and a small amount of organic solvent, such as trichloroethylene, toluol, or proprietary solvents (such as Freon TMC). Remove as much of the melted plastic and flux from the soldered area as possible. Remove excess solvent and dissolved flux with absorbent material.

CAUTION

Use solvent sparingly, since the postcoating will also be dissolved. Apply a small amount to the area of the solder joint only.

(8) Mix one part of Dennis 1169A liquid and one part Dennis 1169B liquid. Mix these two liquids together in a stainless steel, wax-free paper or polyethylene container, and stir with a stainless steel spatula or equivalent. Mix thoroughly.

(9) Apply the Dennis 1169 mixture to the newly soldered joint (or joints), covering all areas where the original coating was damaged and any new components which were added. Use a soft-bristled brush to apply the Dennis 1169.

(10) Allow the newly coated boards to dry to a tack-free condition (approximately 2 hours) before reassembling the mode. The final cure will take approximately 7 days at room temperature or 1 hour at +60° (+140°F). However, the equipment may be operated during the curing period.

g. PARTS LOCATION ILLUSTRATIONS. - Refer to figures 5-1 through 5-13 for parts identification illustrations.

5-4. CABINET INTERCONNECTION CABLING.

A flexible cable is used to connect the three rear connectors, J11, J12, and J13, to chassis assembly connector A6J1. Table 5-2 is a from-to chart which lists cable wires and their functions.

TABLE 5-2. FROM-TO WIRE CHART FOR CABINET INTERCONNECTION CABLE

FROM	TO	WIRE NO.	FUNCTION
P1-A	J11-A	1A	USB audio output
P1-B	J11-B	1B	USB audio output
P1-end	J11-end	1S	USB audio shield
P1-C	J11-D	2A	LSB audio output
P1-D	J11-H	2B	LSB audio output
P1-end	J11-end	2S	LSB audio shield
P1-E	J11-E	3	Radio keyline
P1-L	J12-A	4A	USB audio input
P1-N	J12-B	4B	USB audio input
P1-end	J12-end	4S	USB audio shield
P1-V	J12-D	5A	LSB audio input
P1-P	J12-H	5B	LSB audio input
P1-end	J12-end	5S	LSB audio shield
P1-R	J12-E	6	Equipment ground
P1-G	J13-B	7	115 vac, 400 cps
P1-end	J13-NC	7S	Power shield
P1-H	J13-C	8	115 vac, 400 cps
P1-end	J1e-NC	8S	Power shield
P1-J	J13-D	9	Equipment ground
P1-#1S	P1-#2S	10	Shield
P1-#2S	P1-#4S	11	Shield
P1-#4S	P1-#5S	12	Shield
P1-#5S	P1-S	13	Shield
P1-#7S	P1-#8S	14	Shield
P1-#8S	P1-T	15	Shield

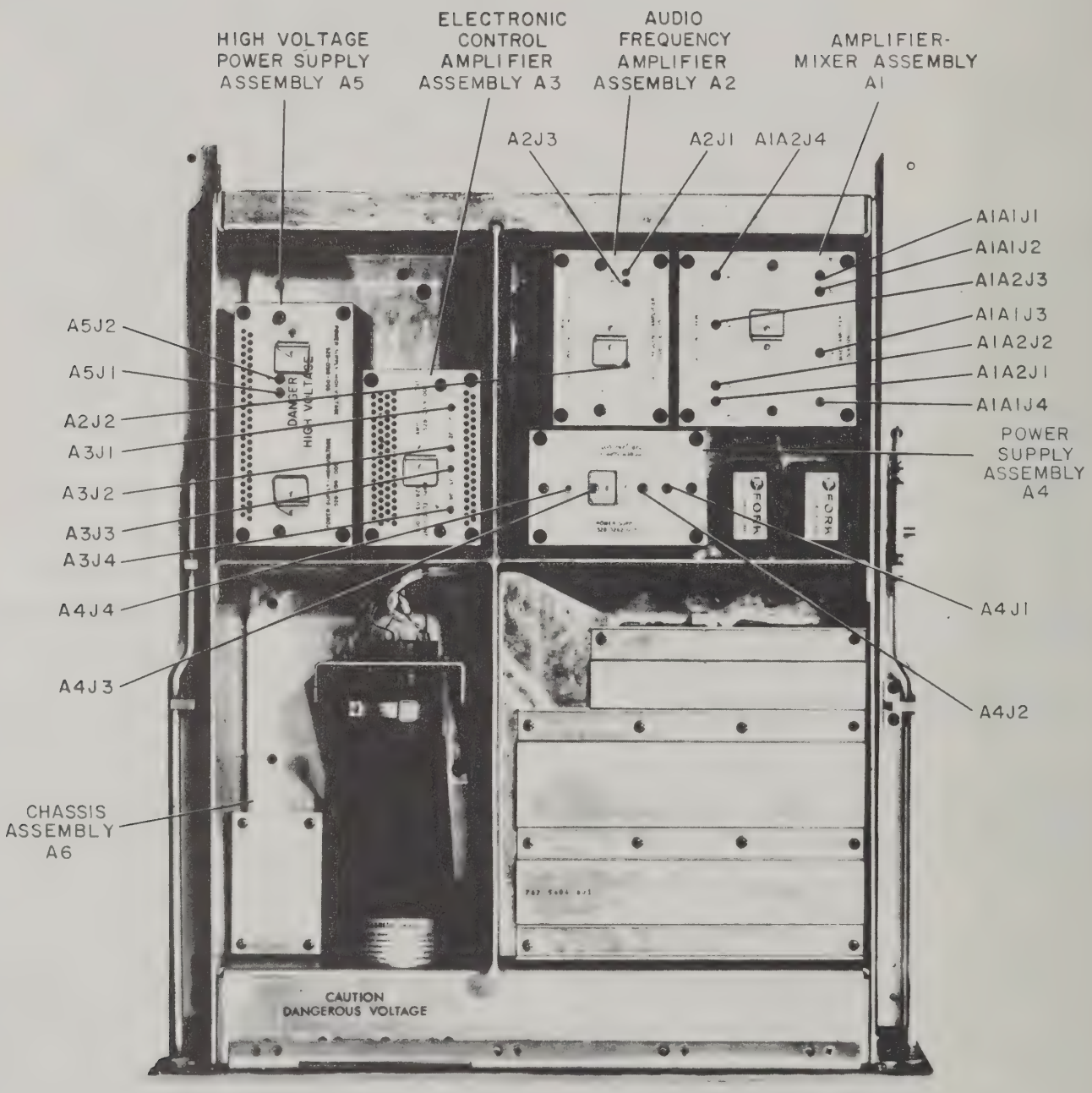


Figure 5-1. Radio Test Set-Monitor TS-2476/SRC-23(V), Top View, Test Point and Assembly Locations

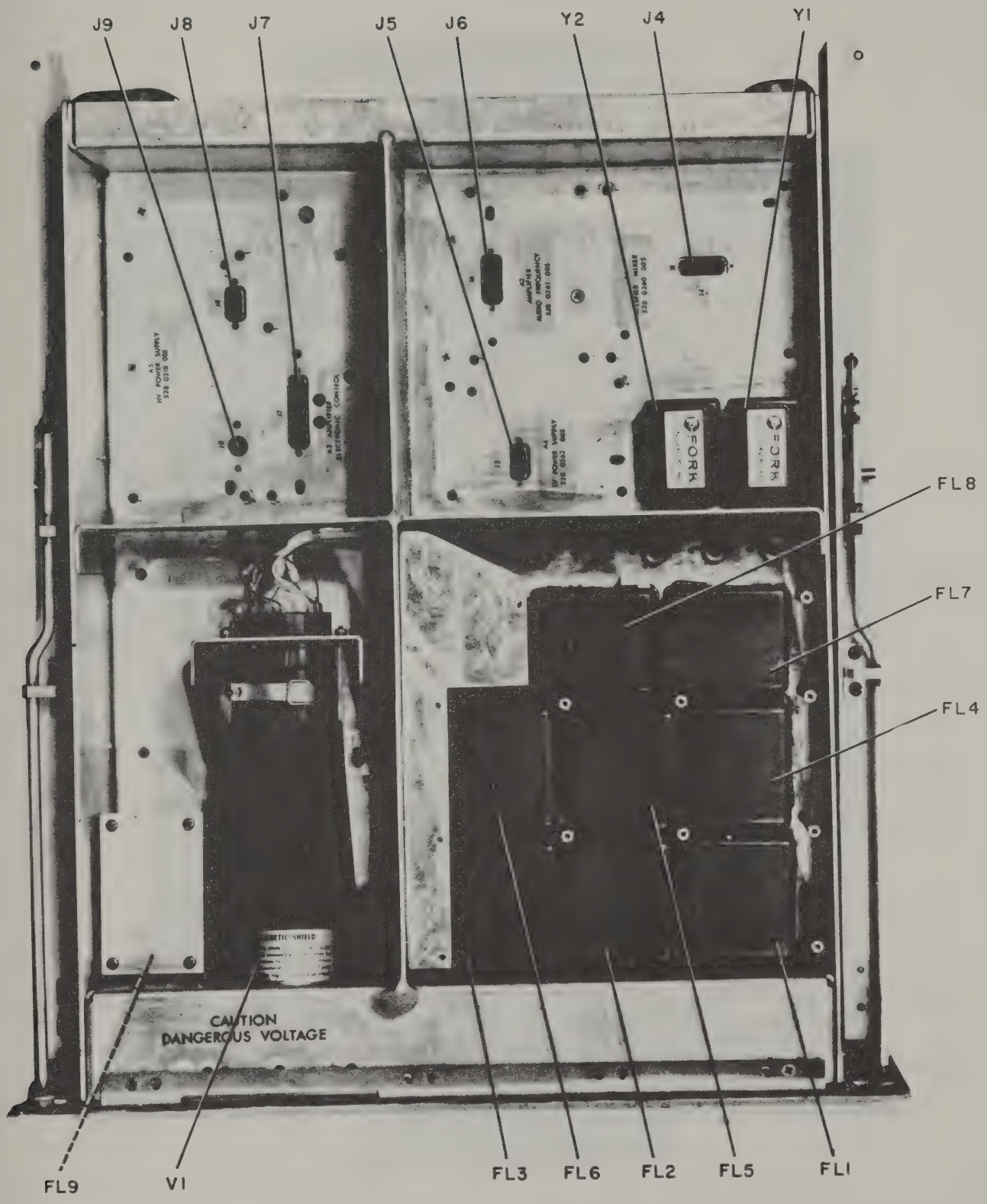


Figure 5-2. Chassis Assembly A6, Top View, Parts Location

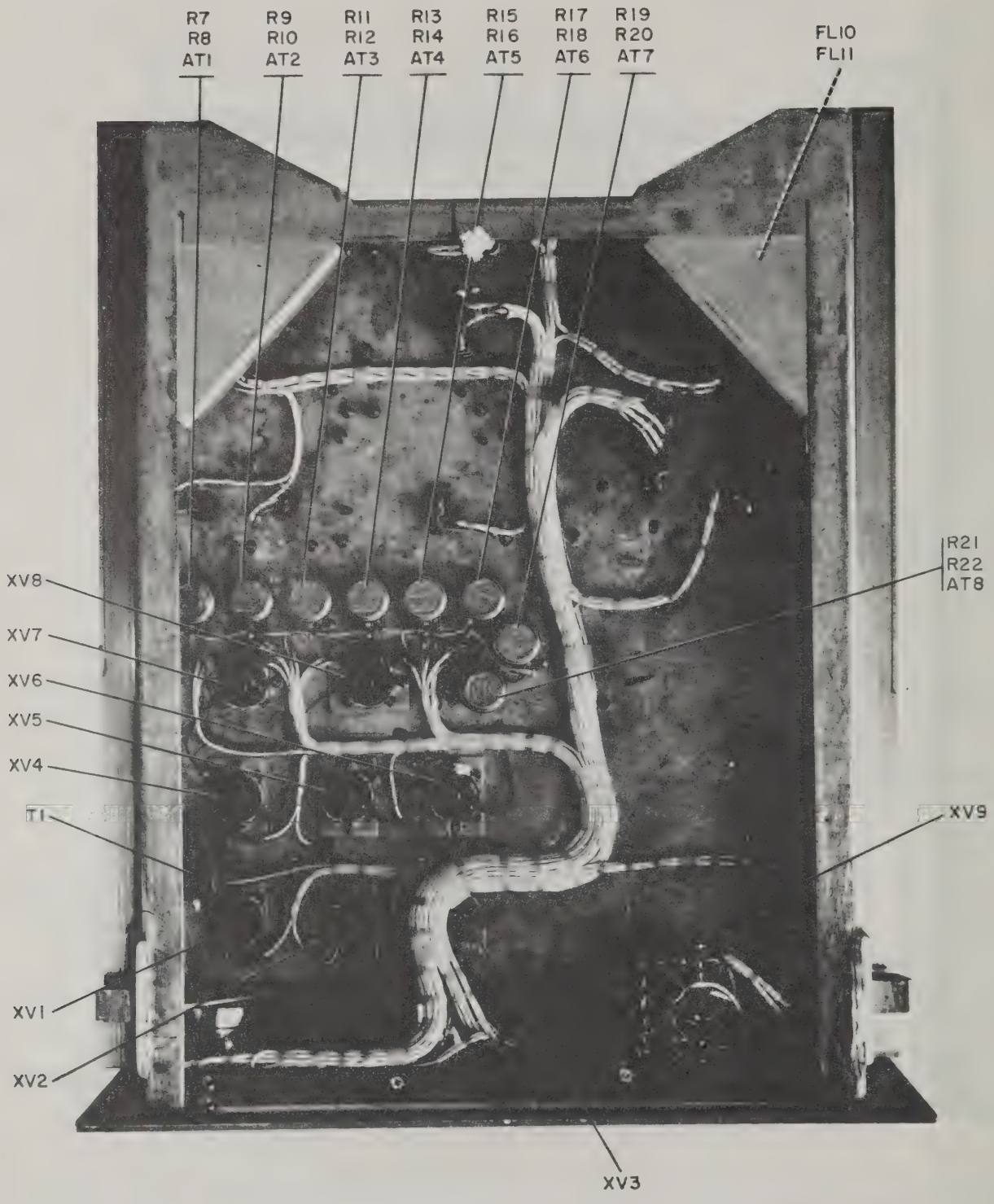


Figure 5-3. Chassis Assembly A6, Bottom View, Parts Location

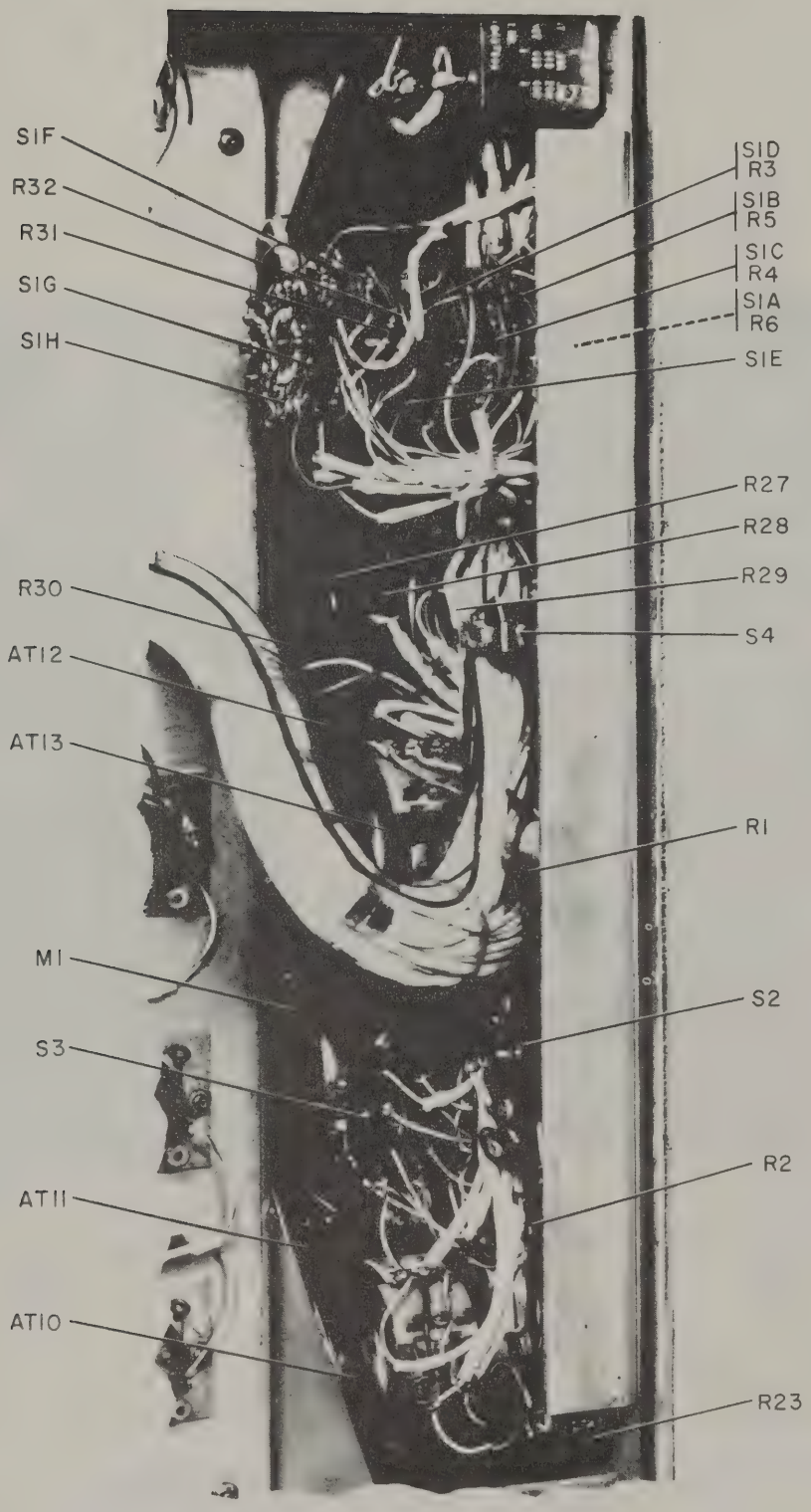


Figure 5-4. Chassis Assembly A6, Rear of Front Panel, Parts Location

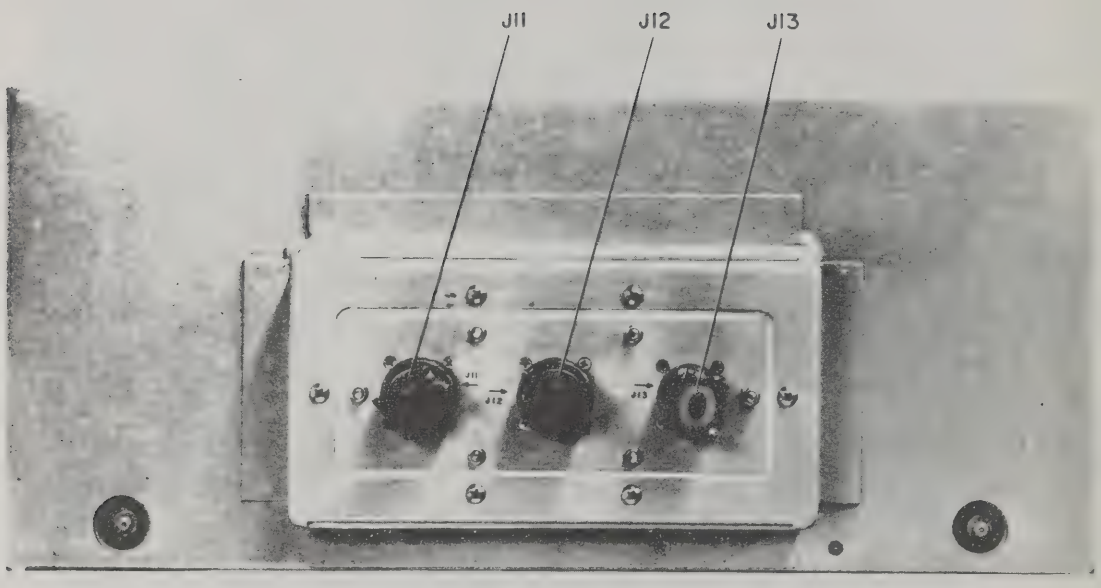


Figure 5-5. Rear View of Cabinet, Parts Location

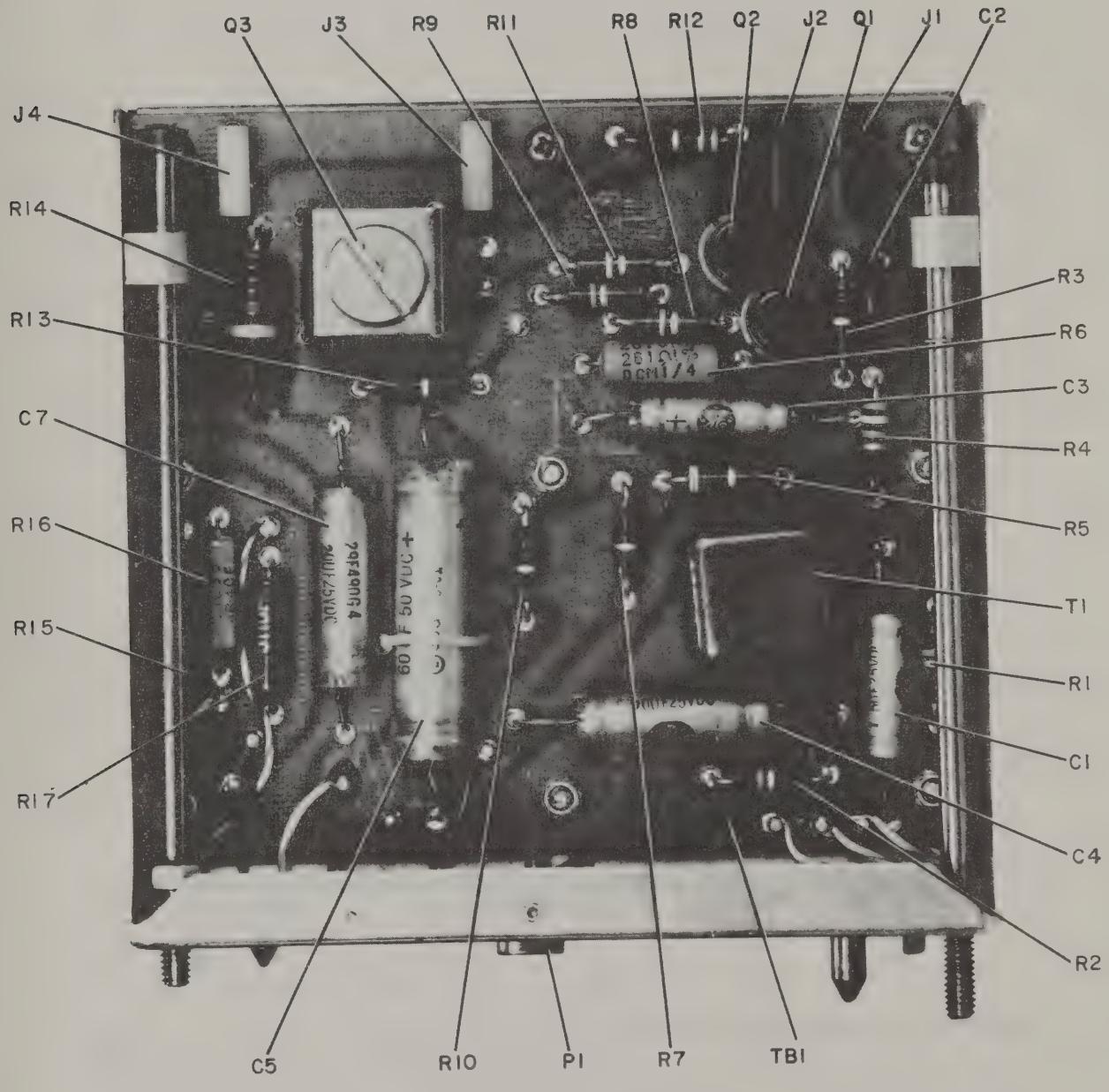


Figure 5-6. Amplifier Mixer Assembly A1, Subassemblies A1A1 and A1A2, Parts Location

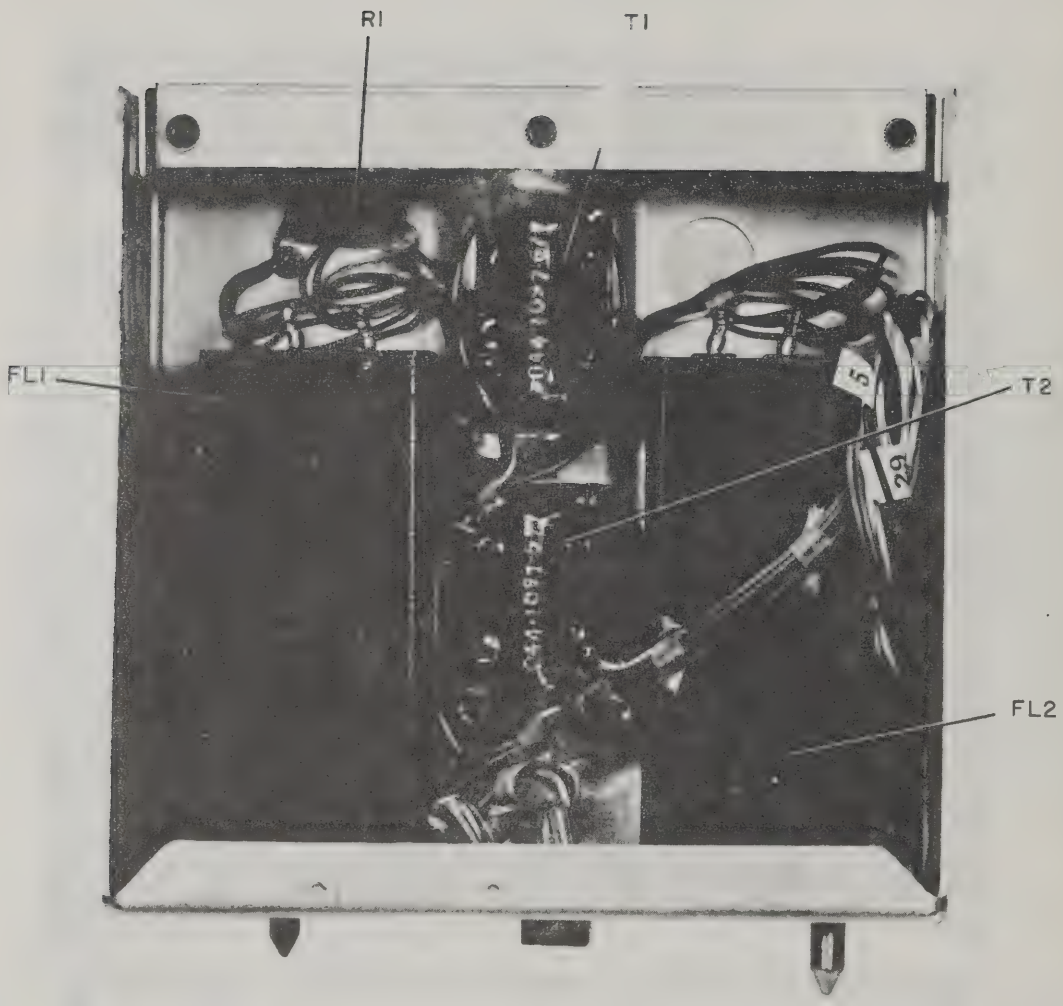


Figure 5-7. Amplifier-Mixer Assembly A1, Mixer Subassembly A1A3, Parts Location

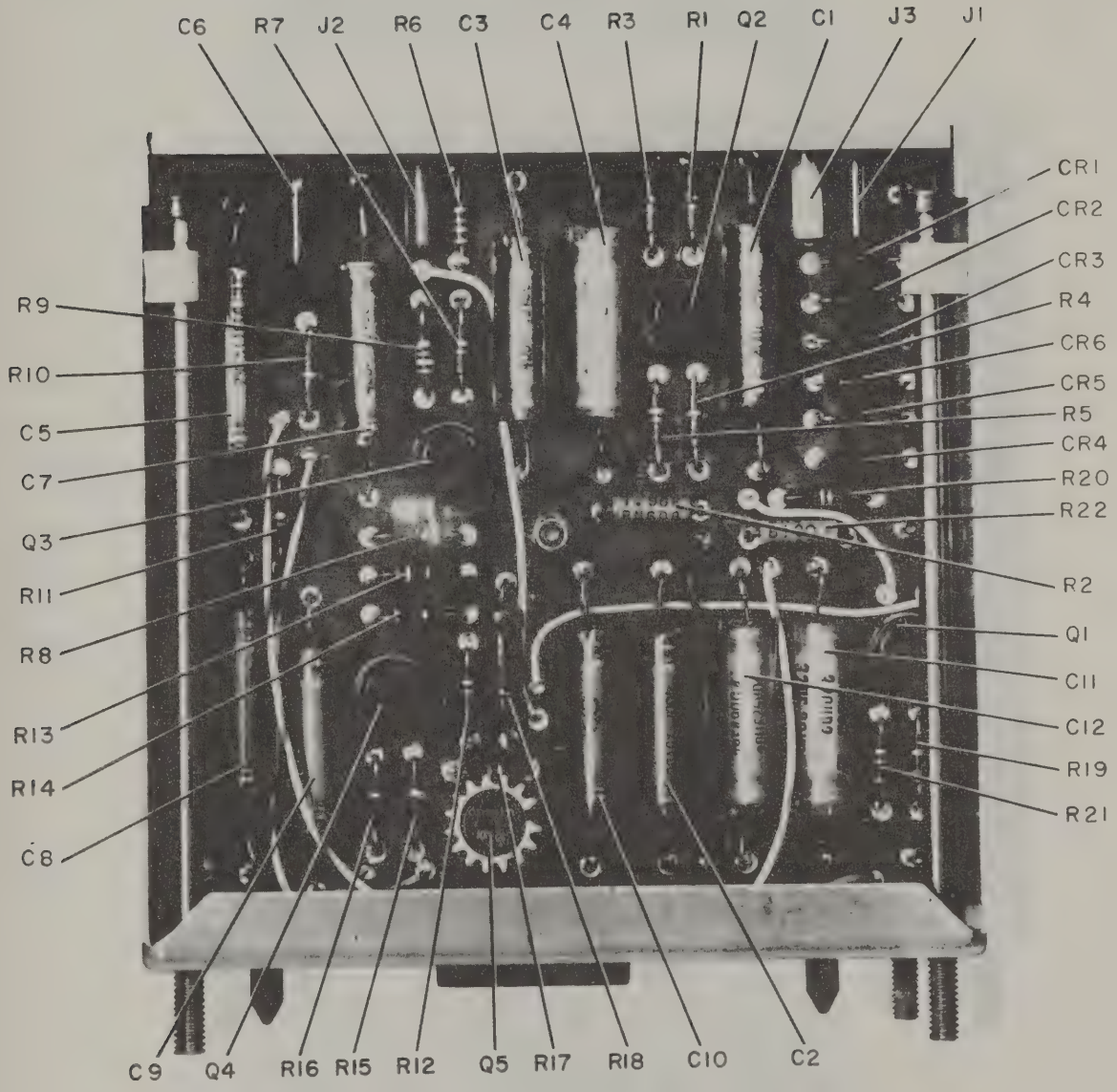


Figure 5-8. Audio-Frequency Amplifier Assembly A2, Parts Location

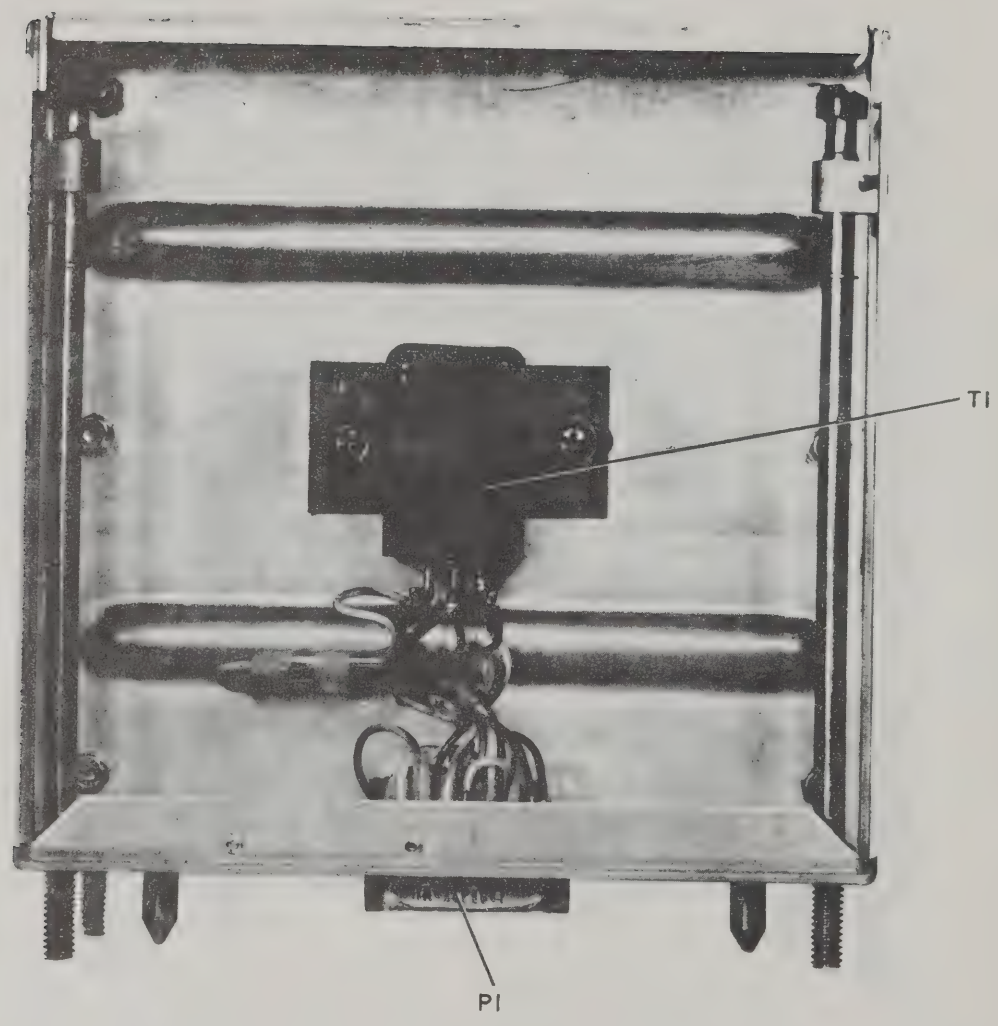


Figure 5-9. Audio-Frequency Amplifier Assembly A2, Parts Location

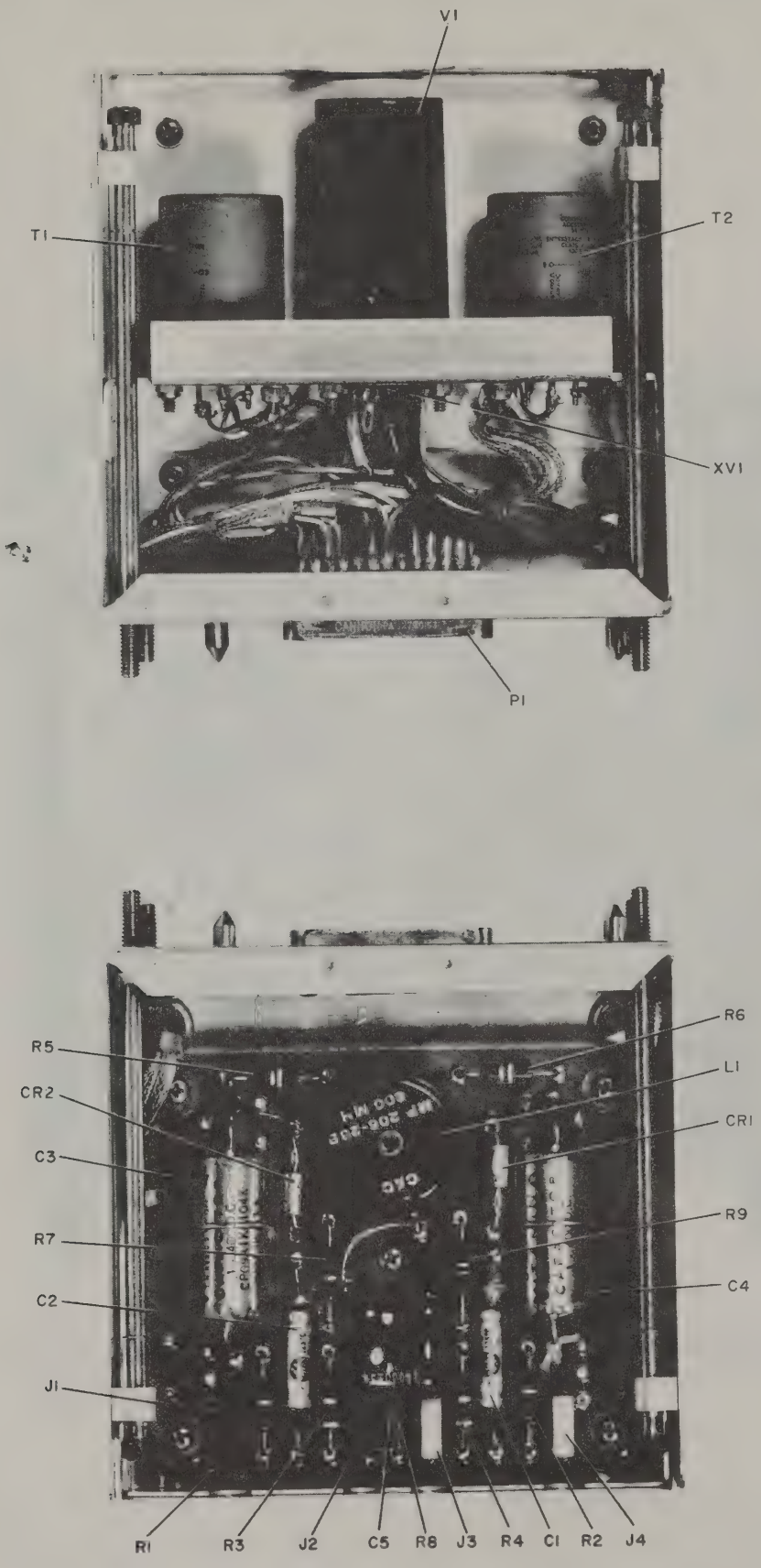


Figure 5-10. Electronic Control Amplifier Assembly A3, Parts Location

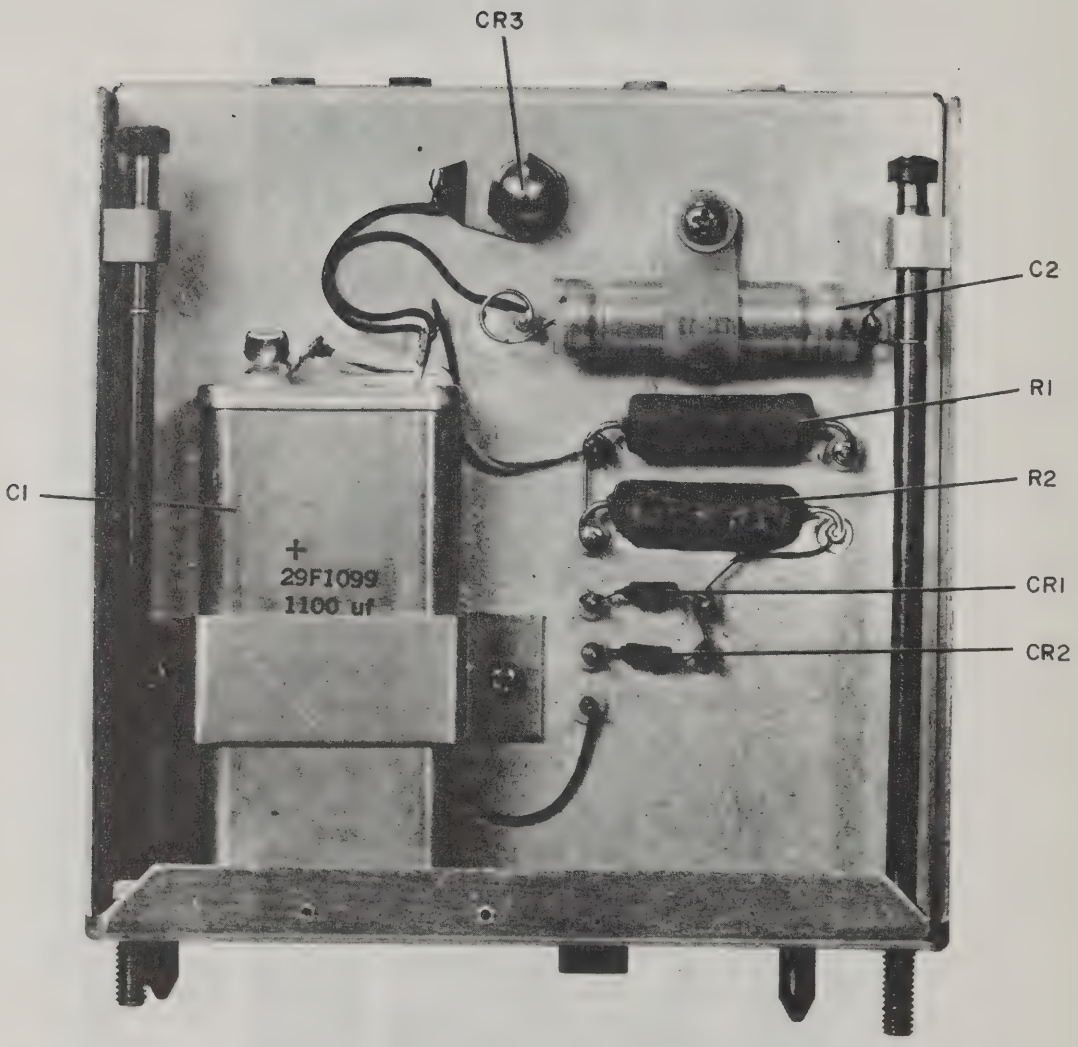


Figure 5-11. Low-Voltage Power Supply Assembly A4, Parts Location

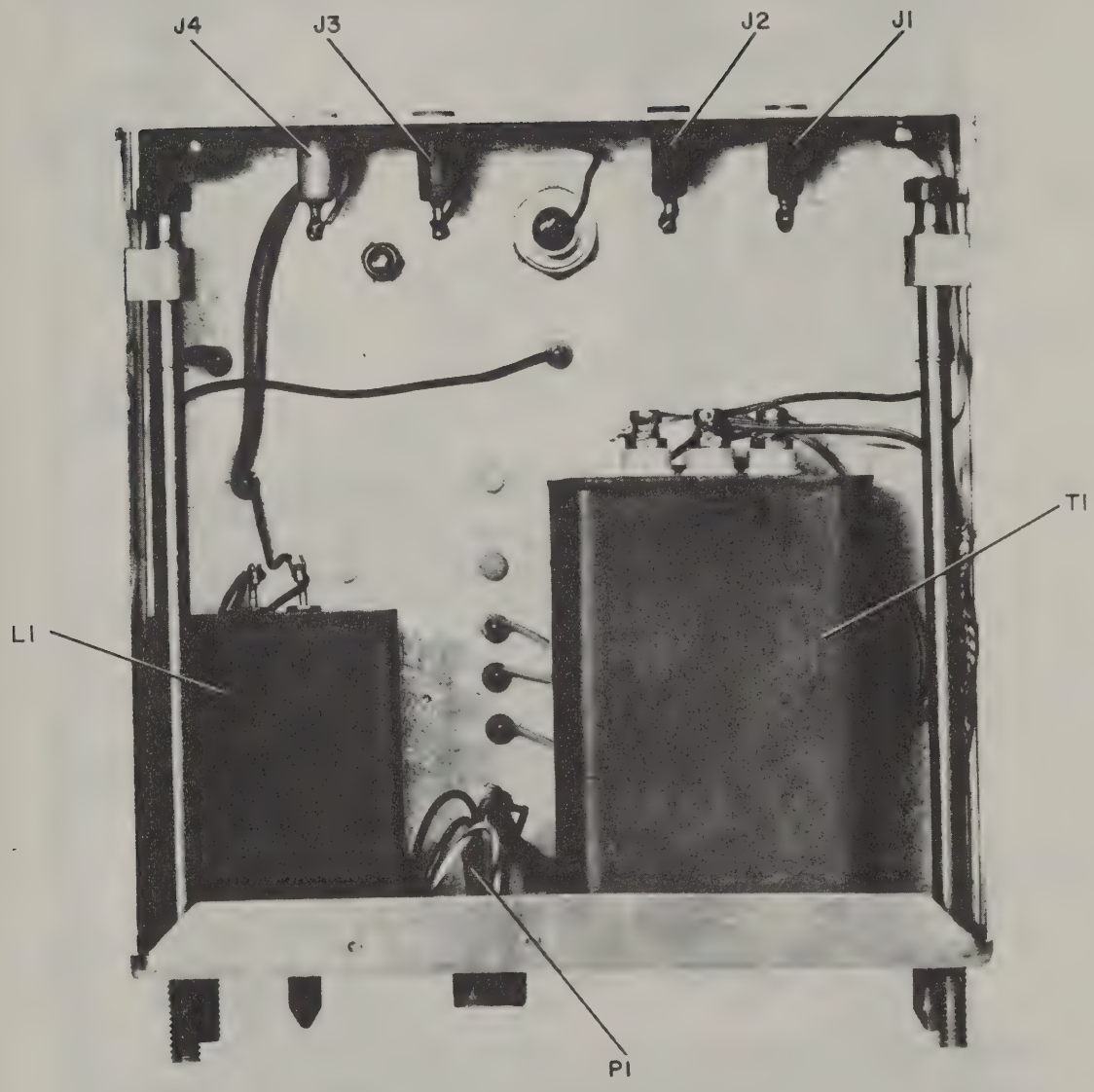


Figure 5-12. Low-Voltage Power Supply Assembly A4, Parts Location

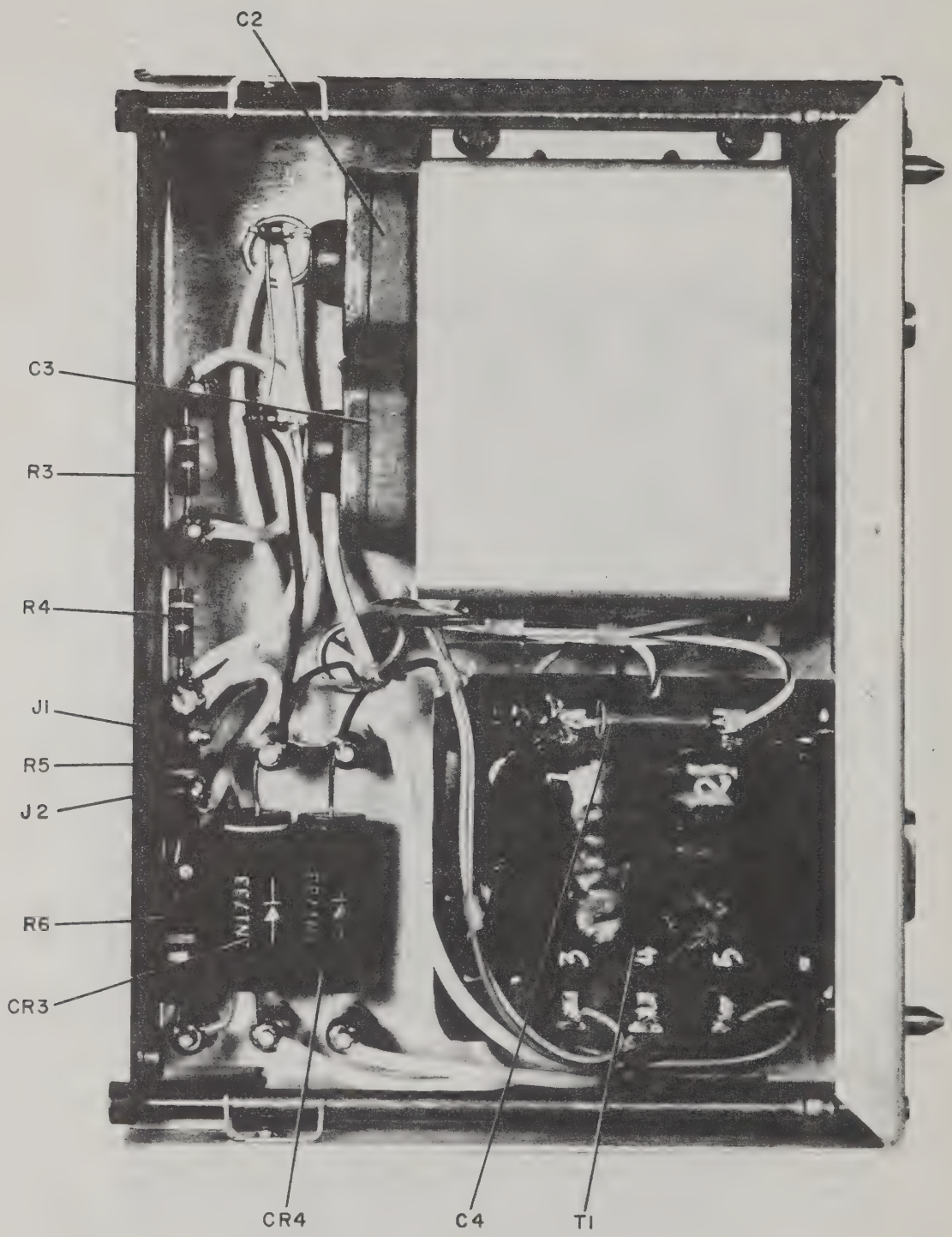


Figure 5-13. High-Voltage Power Supply Assembly A5, Parts Location

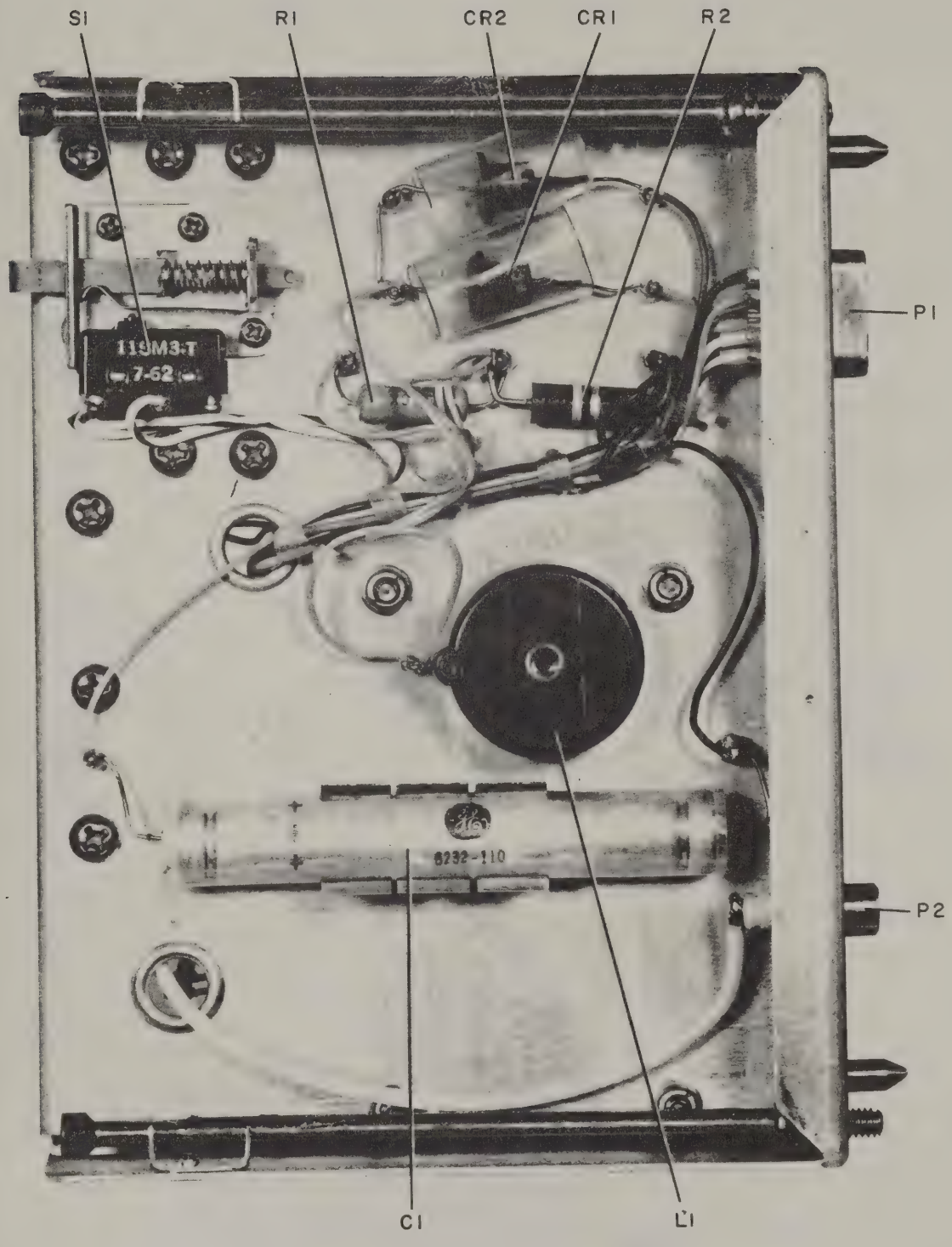
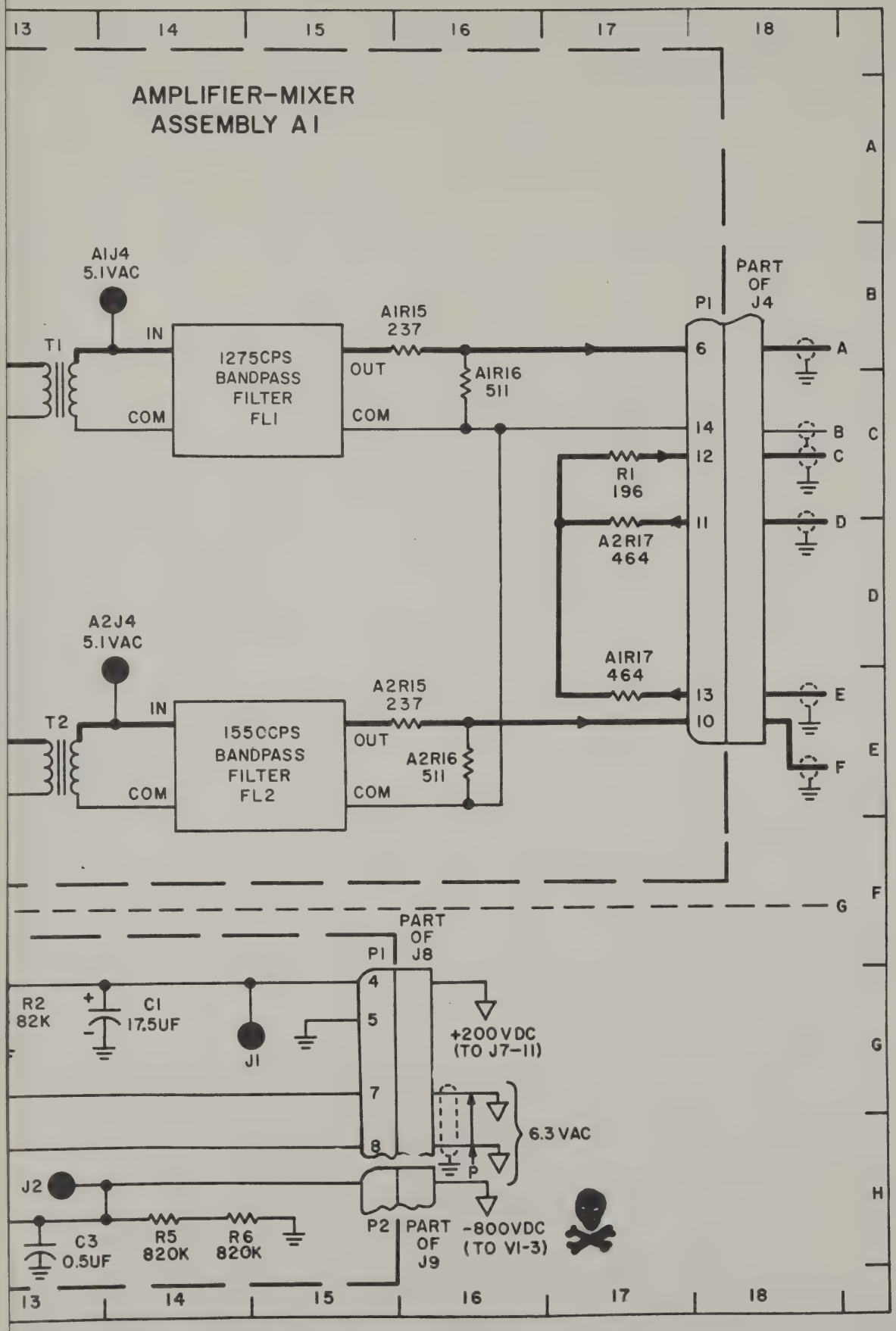


Figure 5-14. High-Voltage Power Supply Assembly A5, Parts Location



5-15. Radio Test Set-Monitor TS-2476/SRC-23(V), Schematic Diagram (Sheet 1 of 3)

REF DESIG	LOC	REF DESIG	LOC	REF DESIG	LOC	REF DESIG	LOC	REF DESIG	LOC	REF DESIG	LOC
A1FL1	15C	A1A2J4	14D	A2Q1	49F	A3R6	49B	A6AT4	35F	A6R9	35E
A1FL2	15E	A1A2Q1	8E	A2Q2	51G	A3R7	51A	A6AT5	37G	A6R10	35E
A1P1	5F	A1A2Q2	10D	A2Q3	52F	A3R8	51C	A6AT6	35G	A6R11	36F
	18B	A1A2Q3	12E	A2Q4	54E	A3R9	46C	A6AT7	37H	A6R12	37E
A1R1	17C	A1A2R1	6E	A2Q5	56F	A3T1	45A	A6AT8	35H	A6R13	35F
A1T1	13B	A1A2R2	6D	A2R1	50F	A3T2	45C	A6AT10	46F	A6R14	35F
A1T2	13E	A1A2R3	7D	A2R2	59E	A3V1A	47A	A6AT11	44F	A6R15	36G
A1A1C1	6C	A1A2R4	7D	A2R3	51F	A3V1B	49C	A6AT12	22C	A6R16	37F
A1A1C2	7A	A1A2R5	7D	A2R4	51G	A4C1	5G	A6AT13	20C	A6R17	35G
A1A1C3	8A	A1A2R6	9D	A2R5	51H	A4C2	8G	A6CB1	3G	A6R18	35G
A1A1C4	9B	A1A2R7	9D	A2R6	51E	A4CR1	5G	A6FL1	39E	A6R19	36H
A1A1C5	10A	A1A2R8	9E	A2R7	52E	A4CR2	5H	A6FL2	39E	A6R20	37G
A1A1C7	12A	A1A2R9	10D	A2R8	52G	A4CR3	7G	A6FL3	39F	A6R21	35H
A1A1J1	6A	A1A2R10	10D	A2R9	53E	A4J1	4G	A6FL4	39F	A6R22	35H
A1A1J2	7C	A1A2R11	10E	A2R10	53G	A4J2	4H	A6FL5	39G	A6R23A	61F
A1A1J3	11A	A1A2R12	11D	A2R11	60H	A4J3	7G	A6FL6	39G	A6R23B	61G
A1A1J4	14B	A1A2R13	11D	A2R12	53E	A4J4	7G	A6FL7	39H	A6R24	54A
A1A1Q1	8C	A1A2R14	11D	A2R13	54F	A4L1	7G	A6FL8	39H	A6R25	53A
A1A1Q2	10B	A1A2R15	16E	A2R14	55E	A4P1	4H	A6FL9	29B	A6R26	28C
A1A1Q3	12B	A1A2R16	16E	A2R15	55G		8G	A6FL10	2G	A6R27	54B
A1A1R1	6C	A1A2R17	17D	A2R16	60F	A4R1	6G	A6FL11	2G	A6R28	53B
A1A1R2	6B	A1A2T1	6D	A2R17	56E	A4R2	5G	A6J1	1G	A6R29	28D
A1A1R3	7B	A2C1	50F	A2R18	57F	A4T1	4G		30G	A6R30	54A
A1A1R4	7A	A2C2	51H	A2R19	55E	A5C1	14G		27A	A6R31	31C
A1A1R5	7A	A2C3	51F	A2R20	50G	A5C2	13H	A6J4	5F	A6R32	32A
A1A1R6	9B	A2C4	51E	A2R21	48E	A5C3	13H		18B	A6S1	24A
A1A1R7	9A	A2C5	60G	A2R22	48G	A5C4	10H	A6J5	3H	A6S1A	27H
A1A1R8	9C	A2C6	53F	A2T1	22E	A5CR1	11G		9G	A6S1B	27F
A1A1R9	10B	A2C7	53F	A3C1	50C	A5CR2	11G	A6J6	21F	A6S1C	25F
A1A1R10	10A	A2C8	60G	A3C2	47B	A5CR3	11H		23H	A6S1D	25D
A1A1R11	10C	A2C9	55F	A3C3	50A	A5CR4	11H		47F	A6S1E	25D
A1A1R12	11A	A2C10	57F	A3C4	50B	A5J1	15G		53E	A6S1F	31B
A1A1R13	11B	A2C11	56E	A3C5	46C	A5J2	13H		61E	A6S1G	31D
A1A1R14	11A	A2C12	48F	A3CR1	51A	A5L1	12G	A6J7	44D	A6S1H	20F
A1A1R15	16B	A2CR1	58F	A3CR2	50A	A5P1	9H		52C	A6S2	3B
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A1A1R17	17D	A2CR3	58G	A3J2	50A	A5P2	15H		16F	A6S2B	2D
A1A1T1	6B	A2CR4	59F	A3J3	51C	A5R1	12G	A6J9	16H	A6S3	42H
A1A2C1	6E	A2CR5	59G	A3J4	48B	A5R2	13G	A6M1	62F	A6S3A	32F
A1A2C2	7D	A2CR6	59G	A3L1	47C	A5R3	12H	A6R1	4B	A6S3B	39F
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A1A2C5	10D	A2P1	22F	A3R1	46B	A5R6	14H	A6R4	24G	A6T1	31H
A1A2C7	12D		23H	A3R2	48C	A5T1	11G	A6R5	28F	A6V1	54C
A1A2J1	6E		47F	A3R3	46B	A6AT1	37E	A6R6	27H	A6Y1	3C
A1A2J2	7E		53E	A3R4	49C	A6AT2	35E	A6R7	36E	A6Y2	3F
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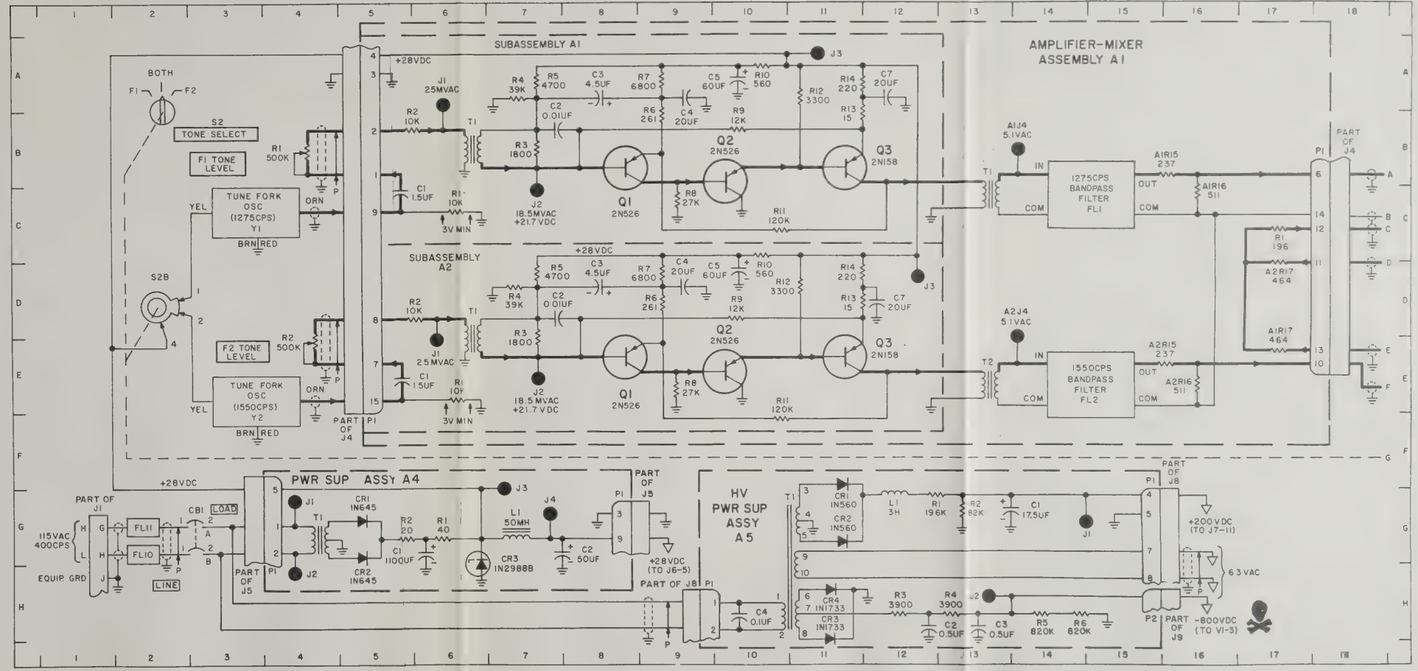
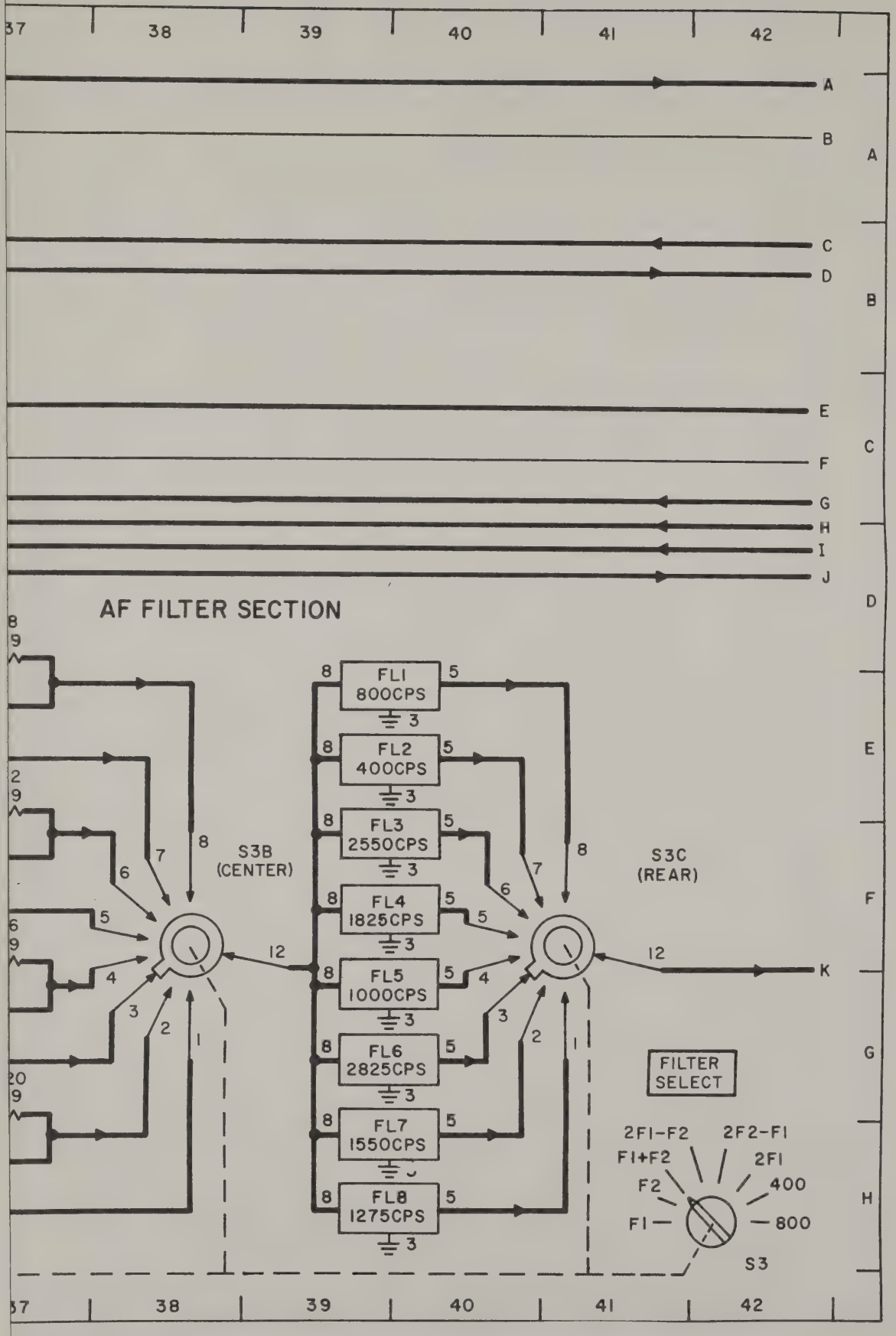


Figure 5-15. Radio Test Set-Monitor TS-2476/SRC-23(V), Schematic Diagram (Sheet 1 of 3)



-15. Radio Test Set-Monitor TS-2476/SRC-23(V), Schematic Diagram (Sheet 2 of 3)

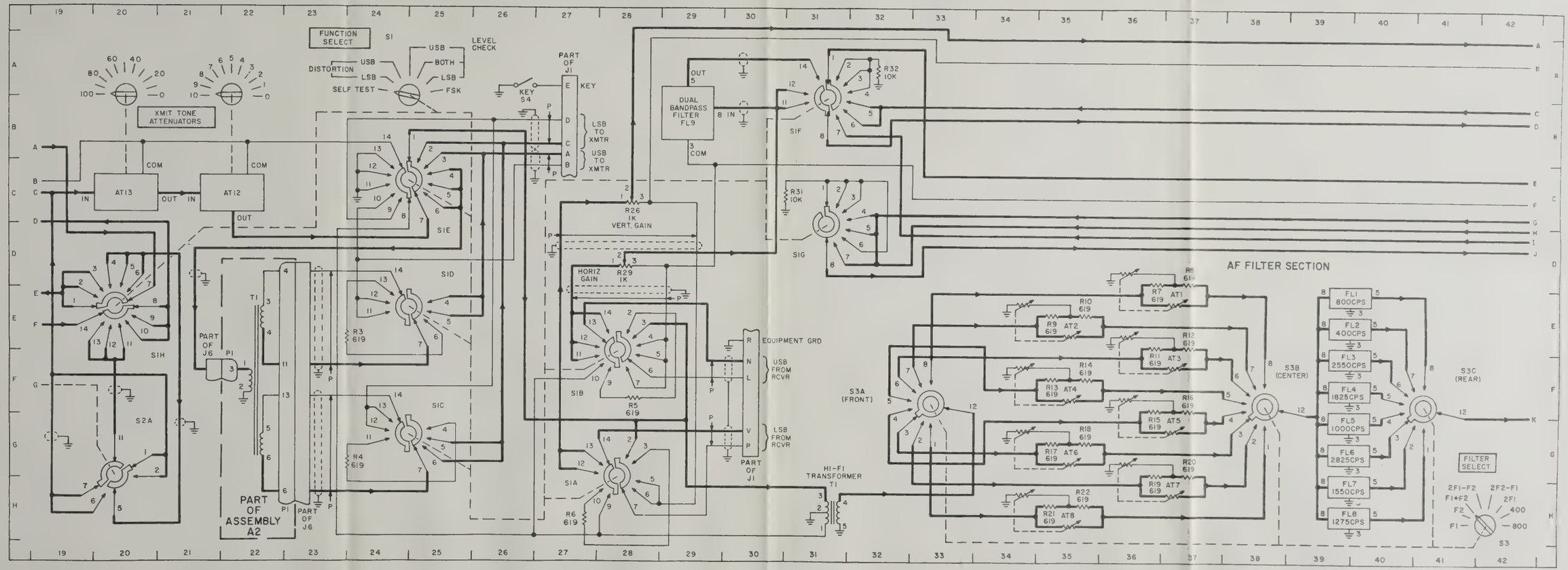
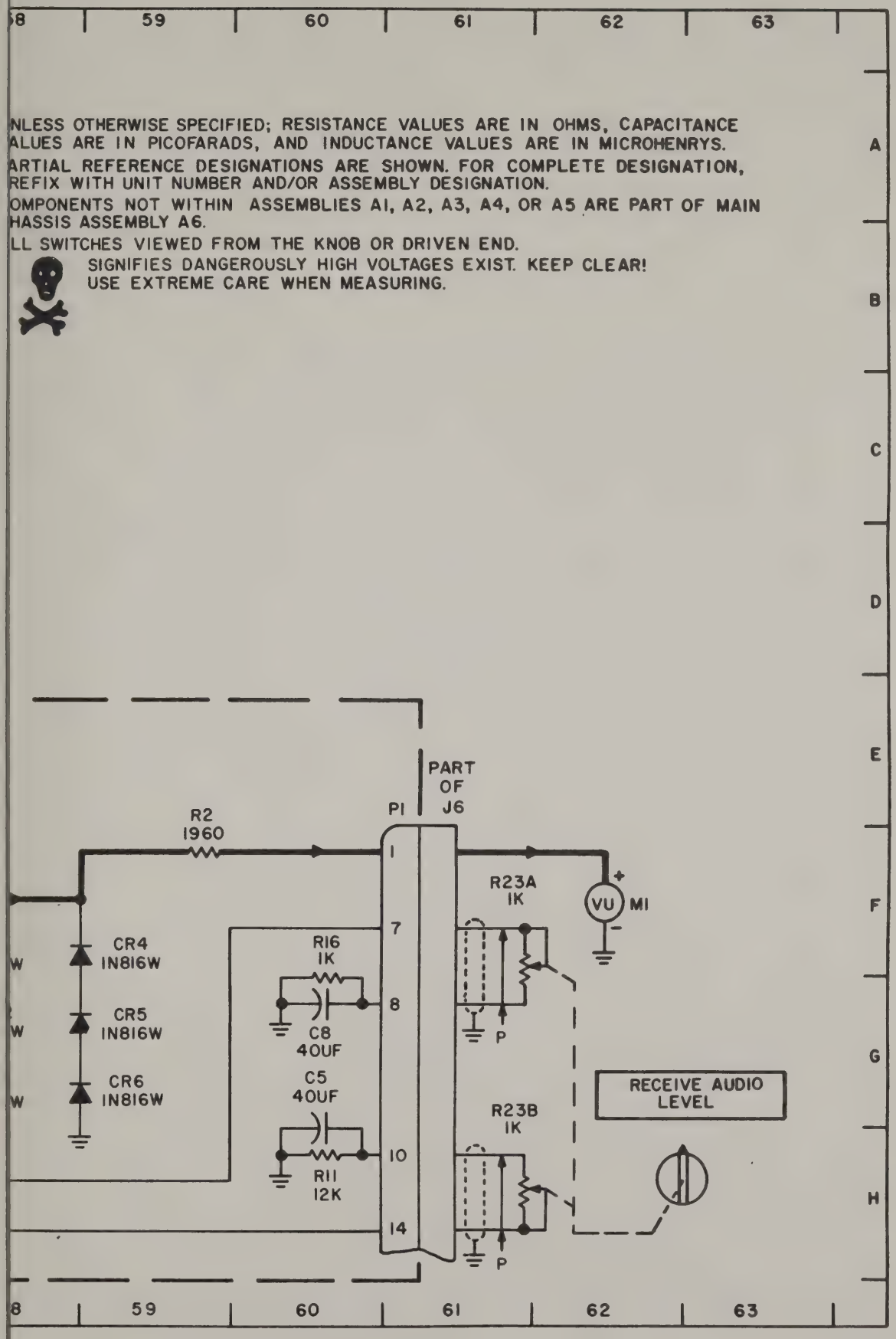


Figure 5-15. Radio Test Set-Monitor TS-2476/SRC-23(V), Schematic Diagram (Sheet 2 of 3)



-15. Radio Test Set-Monitor TS-2476/SRC-23(V), Schematic Diagram (Sheet 3 of 3)

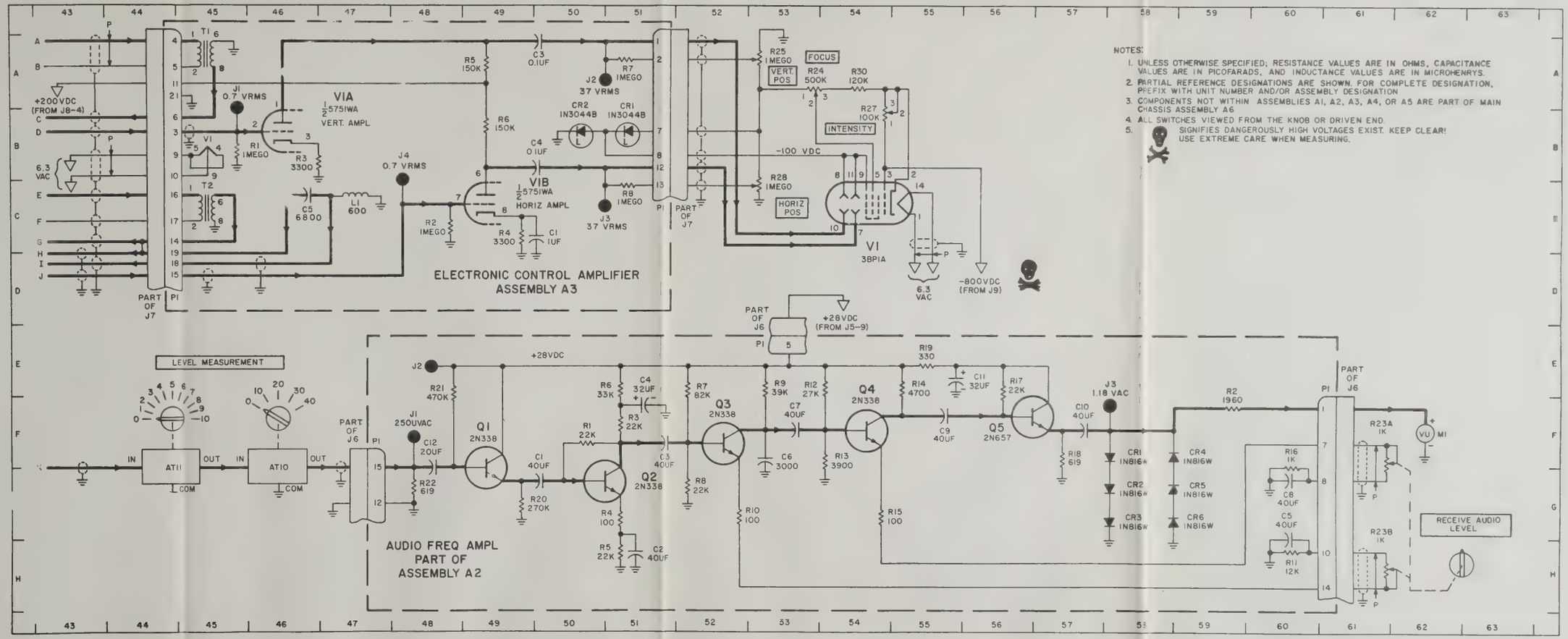


Figure 5-15. Radio Test Set-Monitor TS-2476/SRC-23(V), Schematic Diagram (Sheet 3 of 3)

SECTION 6

PARTS LIST

6-1. REFERENCE.

Refer to chapter O, volume 5.